LABORATORY PRACTICE

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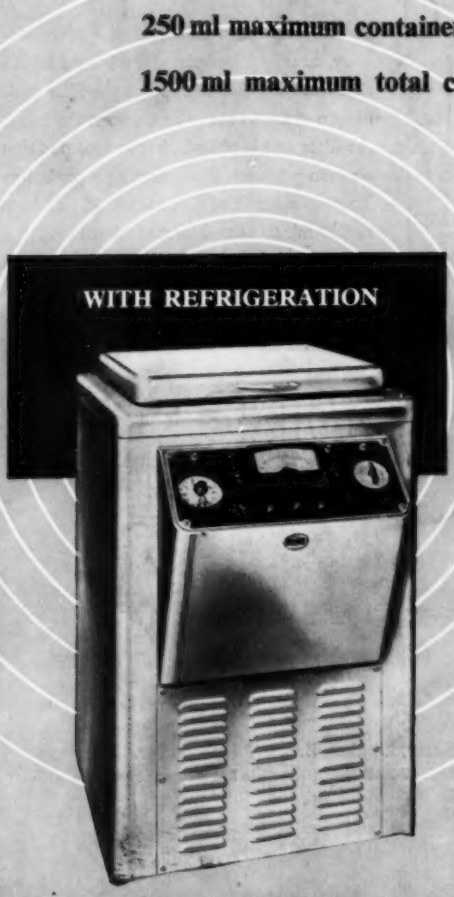

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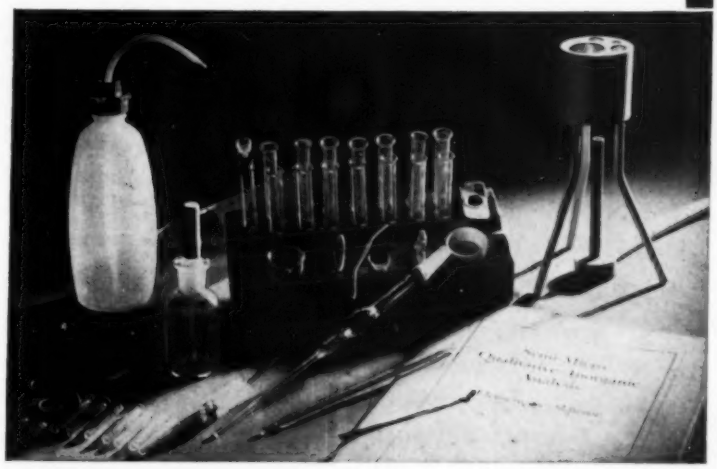

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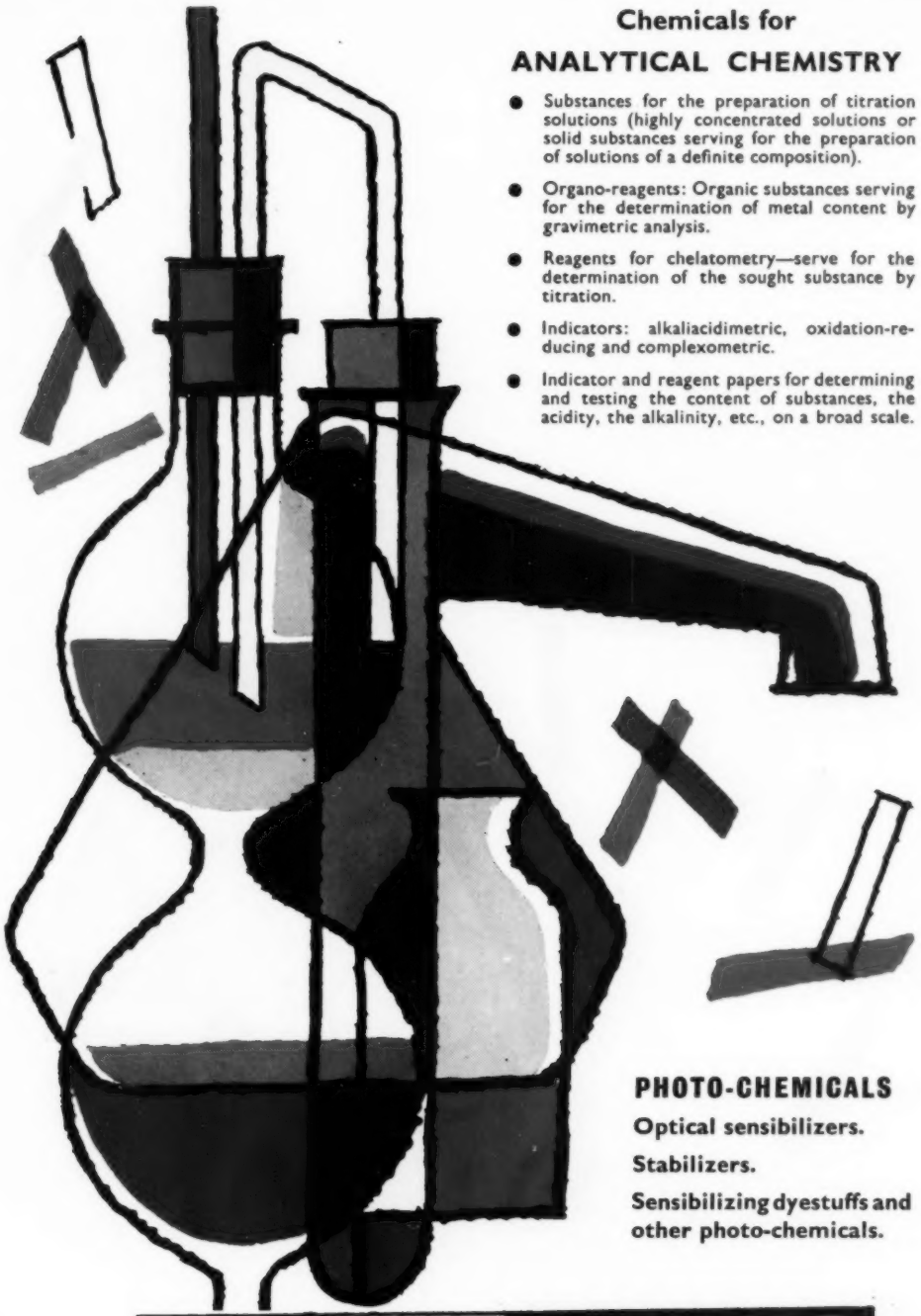

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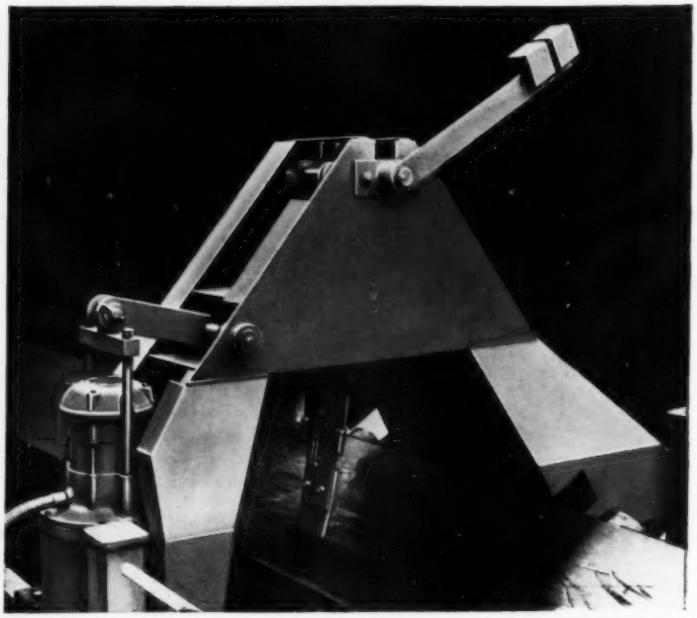

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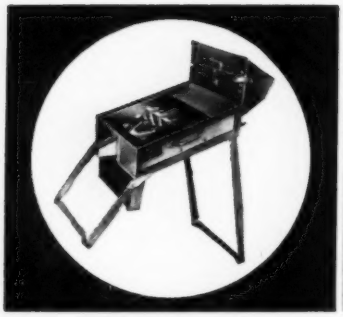

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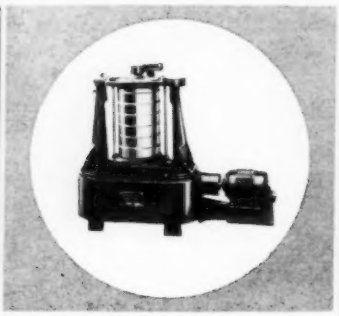

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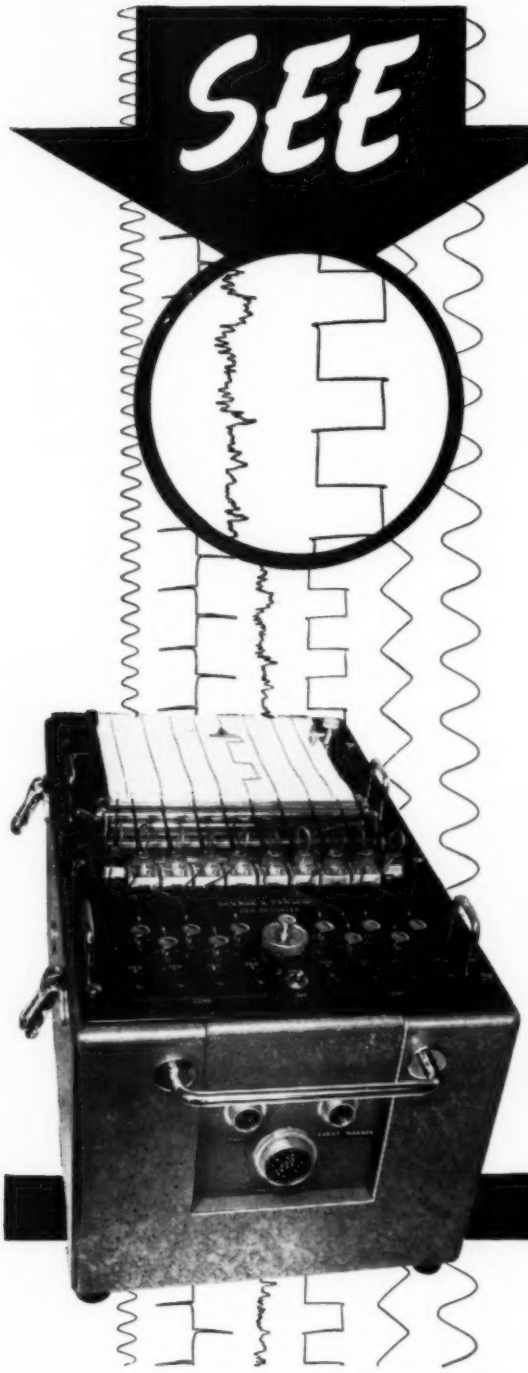

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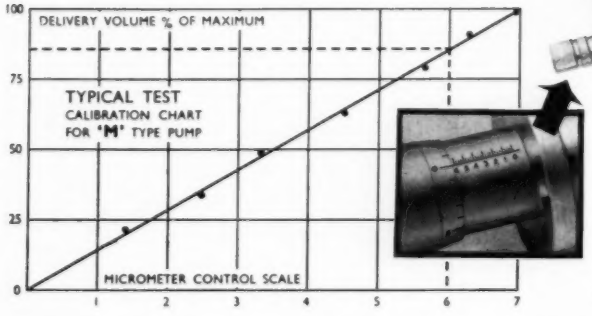

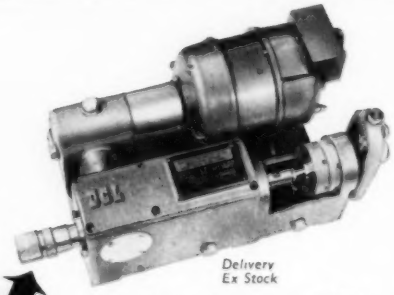

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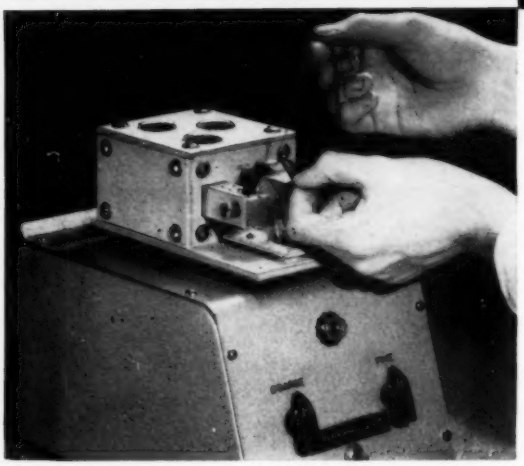

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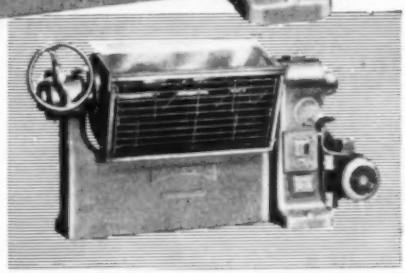

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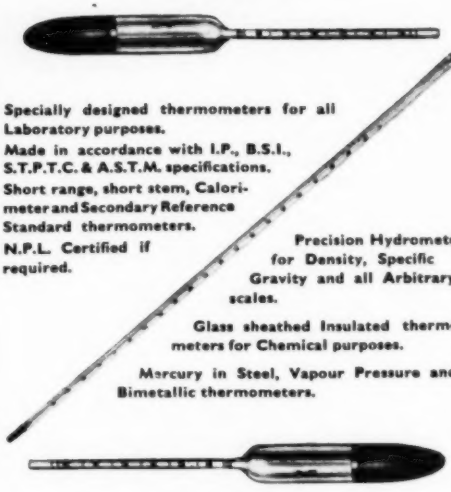

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EDITORIAL

Scientists and the Vote

IN spite of the vicissitudes of history and a never-ending stream of criticism from all sources, the parliamentary form of government has endured in this country for over 700 years, apart from a few minor interruptions. There is little doubt that the strength of the country and the stability of government are largely due to the fact that there have nearly always been two major parties, or two major influences before the present parties took their modern form. Any system of government can be criticized but no one has yet suggested a better alternative acceptable by the majority of the people. Coupled with a constitutional monarchy and an independent legislature, parliamentary government has a stability, dignity and a fairness which probably no other system can imitate.

In theory a parliamentary elector votes for the candidate of his choice, but in practice he votes for a policy which is the proposed method of government favoured by a particular party. It would be very easy to elect a parliament of the 600 most brilliant brains in the country and for the result to be absolute chaos. Unfortunately the cleverest men do not agree any better than the ordinary ones. As with scientific societies, the details of control are decided by a committee, and in spite of the slanderous references to that noble beast the camel, rule by a committee still appears to be the most acceptable even if not the most efficient.

The last century, and especially the last 30 years, have seen a social revolution in this country, and yet our form of government survives. Social changes now take place which would have horrified our grandparents 50 years ago. To make haste slowly is a motto not without its advantages.

One of the most interesting changes is that in suffrage. Within living memory only men in possession of a certain amount of property were entitled to vote; today not only all men but all women over 21 can vote. This forms the basis of one criticism—men and women are obviously not equal in mental ability or any other aspect of their capacity to vote intelligently. Should there be a weighting in the voting system, as there was in effect originally?

Some time ago we attended a meeting of a scientific society in the country and had occasion to call at the local post office. Having to wait while the postmistress discussed the athletic and intellectual prowess of her latest grandson with the customer in front, we cast our eyes on a heap of books on the counter. The top one was entitled 'Willing Lips' and on the cover were portrayed a lady and gentleman in close embrace. Anxious to find out whether the author was a disciple of Jane Austen or Somerset Maugham we opened the book to discover that the story consisted of a series of pictures with a few simple words beneath each picture. An appropriate picture on the back cover rounded off the story. It is a sobering thought to realize that readers of such a book have exactly the same voice, as far as voting goes, in the government of the country as a fellow of the Royal Society, a high court judge, a member of Parliament, a university professor, a high level civil servant or a man who has built up a large and successful business starting from nothing. Is there a case for adjusting voting power to mental ability or to the contribution of the individual to the welfare of the country? If so, how shall qualification be assessed and who shall assess it?

The last piece of special voting prerogative was the university vote, abolished some years ago. Opponents of abolition argued that the presence in the House of a few eminent men owing allegiance to no party would be of benefit to all. There is certainly a good case for this basic idea, but why should these independent members be chosen only by university graduates? Such an electorate, although limited, at least has the advantages of a certain standard of intellectual ability, and of catholicity of interests, because graduates cover nearly all activities in the community. From this point of view, the university vote deserves more merit than the 'professional' or 'guild' method of voting proposed by some.

There is also a case for adjustment of voting power to ability and the degree of responsibility carried. Should not the hard-working husband and father, who shoulders many responsibilities, have more say in running the country than the ne'er-do-well bachelor who is incapable of keeping a job and is in-and-out of prison? Such anomalies are certainly curious, but how can they be rectified?

With the trend in the expansion of the number of scientists and technologists in the country, any system which increased the voting power of the professions would in time lead to scientists having an undue influence in elections. Would this necessarily be a good thing? We cannot see any reason why a scientific training more than any other makes a man fitter to vote or to govern. Our one man—one vote system throws us all into the electoral pot as equals, and while we may not agree that we are equals, we can at least agree that there is no universally acceptable method of assessing the degree of inequality. We vote as citizens, not as scientists or members of any other calling. Democracy can only survive by furthering the spread of knowledge, abhoring the suppression of truth and by the development of education in mind and health so that soon all members of a community can claim to be *mens sana in corpore sano*.

Forthcoming Congresses

Pure Food Centenary—1960

To celebrate the centenary of the 'Act for preventing the Adulteration of Articles of Food and Drink', a conference is to be held in London from September 20 to 23, 1960. Administrators, scientists and food manufacturers from home and overseas will be celebrating this Pure Food Centenary.

When this Act was passed in 1860 it was the first general pure food law to be made in any country and it was the forerunner of the pure food legislation in the Commonwealth, the United States of America and in most countries throughout the world. Since then has grown a new science of food technology and a tradition of good commercial practice has been established by food manufacturers which ensures that all food sold shall be clean and pure.

The proceedings will open with a reception given by Her Majesty's Government at Lancaster House on September 20 and during the conference, which will be held at the Royal Institution of Great Britain, meetings, lectures, an exhibition and laboratory visits will demonstrate the progress made in the past 100 years and show the part which the food chemist plays in improving the quality of food and providing better nutrition and better health.

Among those who have already accepted invitations to read papers are:

J. H. Hamence, M.Sc., Ph.D., F.R.I.C.	President Elect, Association of Public Analysts; Past President, Society for Analytical Chemistry.
E. B. Hughes, D.Sc., F.R.I.C.	Past President, Society for Analytical Chemistry; Past Chairman, Food Group of Society of Chemical Industry.
J. G. Malloch, M.B.E., B.Sc., M.Sc., Ph.D.	Scientific Adviser to the High Commissioner for Canada.
N. C. Wright, C.B., M.A., D.Sc., Ph.D., F.R.I.C., F.R.S.E.	Deputy Director-General Food and Agriculture Organization of the United Nations; Past Chief Scientific Adviser (Food), Ministry of Agriculture, Fisheries and Food.
A. C. Fraser, M.D., D.Sc., F.R.C.P.	Professor of Medical Biochemistry and Pharmacology, University of Birmingham; President British Food Manufacturing Industries Research Association.

The Chairman of the Executive Committee is Dr. A. J. Amos, B.Sc., Ph.D., F.R.I.C. and all who are interested are asked to write for full details and registration forms to the Secretariat, The Pure Food Centenary, 14 Belgrave Square, London, W.1.

Simon Memorial Prize

The First Simon Memorial Prize has been awarded to Dr. H. London, who delivered the Memorial Lecture on 'Superfluid Helium' on October 13 last.

The Simon Memorial Prize has been instituted by the Low Temperature Group of the Physical Society to commemorate the late Sir Francis Simon, who was Lee Professor of Experimental Philosophy and head of the Clarendon Laboratory, Oxford. Professor Simon also took a leading part in the formation of the Low Temperature Group.

The prize (£250) is to be awarded at about three-yearly intervals for distinguished work in experimental or theoretical low temperature physics.

ORIGINAL CONTRIBUTIONS

A METHOD FOR THE PREPARATION OF BACTERIAL DILUTIONS

by A. M. Cook and K. J. Steel *

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Introduction

The preparation of dilutions for the determination of viable counts of bacteria by a colony counting technique is considered to be one of the major sources of error in such a counting technique (Jennison and Wadsworth, 1940). The magnitude of this so-called 'dilution error' increases with the number of dilutions, and hence the fewest possible dilutions should be made to reach the required number of bacteria. Since all dilutions for counting should be plated as soon as possible after preparation, a reduction in the number of dilutions will reduce the time elapsing between sampling and plating. In order to reduce the number of dilutions necessary, one, or both, of two factors can be utilized: (i) a decrease in the volume of the sample and (ii) an increase in the volume of the diluent.

Volume of Sample

The methods in use for measuring the volume of a sample vary in both accuracy and type, ranging from a standard wire loop to volumetric pipettes. The commonest method adopted is the use of 1 ml. straight sided pipettes for the preparation of serial dilutions (1+9, 1+19, 1+99, etc.). This technique has been the subject of extensive study by Wilson *et al.* (1935). Its disadvantages include the time taken to prepare a given dilution, which of necessity must be lengthy.

For the measurement of smaller volumes, a capillary dropping pipette of some kind is generally used. The measurement of volume by the use of drops has been elaborated by many workers (Fildes, 1931; Withell, 1938). An early report of the use of glass capillary pipettes is by Chick (1908) who used pipettes of an external diameter at their tip such that one drop had a volume of 0·02 ml. Selkon and Mitchison (1957) calibrated their dropping pipettes with the aid of a micrometer screw gauge and by measuring the volume of a large number of drops. The fragility of such pipettes and the consequent inaccuracies produced by slight damage to their tips is a serious drawback to their use. In an attempt to overcome this, an all metal dropping pipette was devised by Marston (1948), but this had the disadvantage that the liquid level was not visible.

These disadvantages have been overcome by the introduction of the dropping pipettes of Cook and Yousef (1953). Other methods of measuring small volumes include the use of Kahn pipettes (Tobie and Orr, 1945) and serological pipettes (Snyder, 1947). The use of the micrometer syringe (Trevan, 1925) whilst of high accuracy is not suitable for routine work.

The use of a standard wire loop in the measurement of small volumes of bacterial suspensions for the preparation of dilutions does not warrant much attention due to the inaccuracies involved. Many improvements on the wire loop have been suggested since the volumes removed by loops were first examined by Duyser and Lewis (1914). However, the use of a standard loop can only be justified in cases where convenience and speed are more necessary than accuracy.

Volume of Diluent

The only limit which can be placed upon the volume of diluent is that of ensuring that mixing of the sample with it is efficient, and that the resultant dilution is homogeneous.

Inaccuracies in the volume of the diluent also contribute to the total error in the preparation of dilutions. Unless the diluent is aseptically transferred to the 'dilution blanks', a further loss of volume may occur during sterilization. Murray (1956) has reported a loss in weight of 1 to 1·5 per cent, depending on the time and temperature, on autoclaving his dilution blanks which were sealed with Astell rubber seals. It has been found however that if care is taken in the use of the autoclave, dilution blanks may be sterilized without breakage or loss in volume of the diluent.

Mixing Methods

The commonest methods of mixing include: aspiration-gravity flow methods with pipettes, hand rolling or shaking, mechanical shaking and magnetic mixing (Phillips *et al.* 1955).

Mechanical methods of mixing have the advantages of ease of manipulation and increased speed in the preparation of dilutions. A method of preparing dilutions involving shaking has been published by Murray (1956), together with a comparison of results obtained by serial dilution techniques. Since his colony counts were based on the mean of only two replicate plates for each replicate dilution of sample, it is possible that his sampling error may be large.

The object of the investigation described in this section was to prepare dilutions by the use of both small volumes of sample and large volumes of diluent. For this purpose the dropping pipettes of Cook and Yousef (1953) and dilution blanks of 50 to 300 ml. were used, together with mechanical mixing.

*Present address: National Collection of Type Cultures, Central Public Health Laboratory, Colindale Avenue, London, N.W.9.

EXPERIMENTAL DETAILS

A. Materials

(i) *Test Organism.*—A laboratory strain of *Escherichia coli* type I, formerly N.C.T.C. No. 5933 was used.

(ii) *Medium.*—The peptone agar used contained 1 per cent of Oxoid peptone, 0·5 per cent of sodium chloride and 1·5 per cent of Davis bacteriological agar. It was prepared with water distilled from a stainless steel still, and the reaction of the medium was adjusted to pH 7·2.

(iii) *Dropping Pipettes.*—These were of the type described by Cook and Yousef (1953). Four needles were calibrated and the 95 per cent confidence limits of the weight of single drops of water delivered were 17·14-17·20 mg., thus the volume of one drop of water delivered from any of the needles may be taken as 1/58 ml. The possible change in drop-weights after prolonged usage may be neglected since after 24 months use, during which period the needles had been sterilized numerous times by autoclaving, boiling and dry heat, the confidence limits of a single drop of water from any of the needles were 17·08-17·14 mg.

(iv) *Dilution Blanks.*—The diluent used was water, distilled from a Manesty still. It was shown to be suitable for the preparation of dilutions and had no adverse effect upon the organism used.

The containers used for the diluent are listed in Table I together with the volumes of diluent. It was decided to use standard M.R.C. blood bottles for the larger volumes, in place of one pint McCartney bottles, by virtue of their greater robustness, shape which allows easier cleaning and handling, and wider necks. The dilution blanks were filled by means of automatic pipettes and sterilization was carried out by autoclaving at 115-116° for 30 to 40 minutes. The loss in weight on sterilization was of the order of 0 to 20 mg. and thus could be neglected. Occasionally a much greater loss was found, due to a faulty seal or chipped neck, and the bottle was rejected.

B. Technique

(i) *Preparaton of the Bacterial Suspension.*—A suspension of the test organism was prepared from the 24-hour growth on peptone agar slopes. The suspending fluid used was distilled water. The suspension was shaken with glass beads in order to break up any aggregates of organisms, and then centrifuged to separate any pieces of the medium which may have been removed from the surface of the slopes. The supernatant suspension was removed and standardized to contain about 2×10^9 organisms per millilitre. In standardizing the suspension the Gambrell clinical photoelectric colorimeter was used as a densiometer.

(ii) *Method of Mixing.*—Mixing was carried out with the aid of a mechanical shaking machine (large model shaker S.360, supplied by Townson and Mercer Ltd., Croydon), operating in a horizontal plane with a to-and-fro movement. For efficient mixing it was found that the containers should be approximately one-third to one-half full (Table I). Preliminary experiments indicated that a stroke of ½ in. did not permit sufficient agitation and turbulence to ensure satisfactory mixing. Similarly, a speed of 150 strokes per minute was not sufficiently fast under the experimental conditions. Eventually a stroke of 1 in. and a speed of 200 strokes per minute was chosen as the most suitable combination.

The Preparation of Dilutions

In determining the viable count of bacteria, the time involved in the preparation of dilutions should be reduced to a minimum, consistent with ensuring homogeneity of the prepared dilutions.

Dilutions of a suspension of *E. coli I* were prepared by shaking for varying periods from one to five minutes; the dilutions were sampled and the number of viable organisms determined. Preliminary experiments using 200 ml. dilution blanks showed no significant difference in the counts obtained from any of the time treatments. Practically, however, a period of five minutes is too long for routine work.

Further experiments were devised using the range of dilution blanks and shaking times of 1, 1½ and 2 min. Samples were removed from three positions in the container, (i) ½-1 cm. below the surface, (ii) the centre and (iii) ½-1 cm. from the bottom. Counts were performed

TABLE I

The Dilution Blanks

Nominal Volume of Diluent ml.	*Container*	*Average Capacity of Container ml.*	*Amount Occupied by Diluent %*	*Mean Volume of Diluent, with Standard Deviation ml.*
50	5 fl. oz. McCartney bottle	144	35	50·00 ± 0·21
100	10 fl. oz. ,, ,,	300	33	100·07 ± 0·24
150	10 fl. oz. ,, ,,	300	50	150·19 ± 0·43
200	1 pint M.R.C. blood ,,	582	34	200·52 ± 0·51
250	1 pint ,, ,, ,,	582	43	249·46 ± 0·18
300	1 pint ,, ,, ,,	582	51	299·43 ± 0·20

TABLE II

Comparison of the Viable Count of a Bacterial Suspension by Three Dilution Methods

	Method I	*Method II*	*Method III*
Number of viable organisms per millilitre ...	$8{\cdot}88 \times 10^8$	$8{\cdot}68 \times 10^8$	$9{\cdot}03 \times 10^8$
Standard deviation	$\pm$ 0·54	$\pm$ 1·07	$\pm$ 1·21
Coeff. of variation	3·67%	7·15%	6·83%
Time taken to prepare and plate one replicate ...	6-7 min.	11-12 min.	8-9 min.
Number of dilutions	2	6	3

by the overdried plate technique of Miles and Misra (1938), the samples removed being dropped directly on to the surface of the medium. This method was used as it is conducive to greater replication and is more accurate than conventional pour-plate methods.

To increase technical efficiency, a multiple pipette holder was designed (Cook *et al.* 1956).

After incubation for 12 to 15 hours, the resulting colonies were counted with the aid of an illuminated colony counter and a hand tally.

An analysis of variance of the results obtained showed that the between sampling positions variance did not reach significance with any of the three shaking times. The between volumes variance however was highly significant with 1 min. shaking and just reached significance with 1½ min. shaking. As the same batch of medium was used for all the counts there will be no between media variations.

From a consideration of the results, a shaking period of 2 min. was decided upon for all volumes. Under these conditions, the effect of shaking on the temperature of the dilution blanks was negligible, the maximum increase recording being 0·9°.

A Comparison of Three Dilution Methods

A suspension of *E. coli I* containing about 10^9 viable organisms per millilitre was used. Dilutions were prepared as follows so that the final dilution contained about 1,000 viable organisms per millilitre.

Method I.—Three drops of suspension from a Cook and Yousef dropping pipette were added to 50 ml. of diluent; three drops of this dilution were added to a further 50 ml. of diluent. Each dilution was shaken mechanically for 2 min. at 200 (1-inch) strokes per minute.

Method II.—Serial dilution technique, 1 ml. of suspension + 9 ml. of diluent.

Method III.—Serial dilutions, 1 ml. of suspension + 99 ml. of diluent.

In methods II and III, 1 ml. pipettes were used as described by Wilson *et al.* (1935) i.e. the liquid was first sucked up and down 10 times to thoroughly wet the interior of the pipette; the contents of the pipette were blown out with the tip touching the side of the container, three seconds were allowed for draining and the accumulated drop was blown out. The dilution blanks were mixed by hand shaking 25 times, each shake being an up-and-down movement with an excursion of about 12 inches, the whole shaking lasting about 12 seconds.

Each dilution method was carried out in quintuplicate.

From the final dilution of each series, 12 drops were transferred by a Cook and Yousef dropping pipette on to the surface of each of six overdried plates. After the drops had been absorbed, the plates were incubated at 37° for 15 hours. The number of colonies which had developed in each drop area was counted, and the viable counts calculated. Table II shows a comparison of the results obtained by the three methods.

These results show that whilst all three methods gave approximately the same value for the viable count, the standard deviation and coefficient of variation were smaller with method I. The smaller number of dilutions in this method are reflected in the shorter time necessary to prepare and plate a given dilution; thus more replicate counts could be made in the time usually allotted to a count by serial dilution methods.

Conclusions

The method described appears to be more efficient than the classical methods available for the preparation of bacterial dilutions. Besides being quicker, it is more economical in apparatus. The method is well suited for experiments with phenolic bactericides, as the first dilution would immediately and effectively 'dilute out' the bactericide.

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A DROPPING PIPETTE FOR SURFACE PLATE COUNTS AND FOR FILLING AMPOULES

by R. A. Lelliott, M.A.

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CONTRARY to the experience of Wills (1959) and Wolochow (1959), Davis and Bell (1958 and 1959) have found dropping pipettes of the hypodermic needle type unsatisfactory for use with the Miles and Misra surface plate method of estimating number of viable cells in a bacterial suspension.

A pipette of this type, mounted on a syringe barrel (Fig. 1) and clamped to a stand, has been used in this laboratory over the last three years both for plate counts and for introducing constant volumes of bacterial suspensions into ampoules for freeze-drying, without experiencing the disadvantages listed by Davis and Bell. The standard errors per drop for three runs each of 15 drops with the pipette mounted as in Fig. 1B. (A in Table 1) and the pipette held in the hand and operated with a teat (B in Table 1) indicate that volumes of drops will be much more constant when pipettes are rigidly supported than when held in the hand. This is probably because of the greater ease with which a more constant rate of drop formation can be achieved, absence of variation in the angle at which the pipette is held, and less tendency for drops to be shaken from

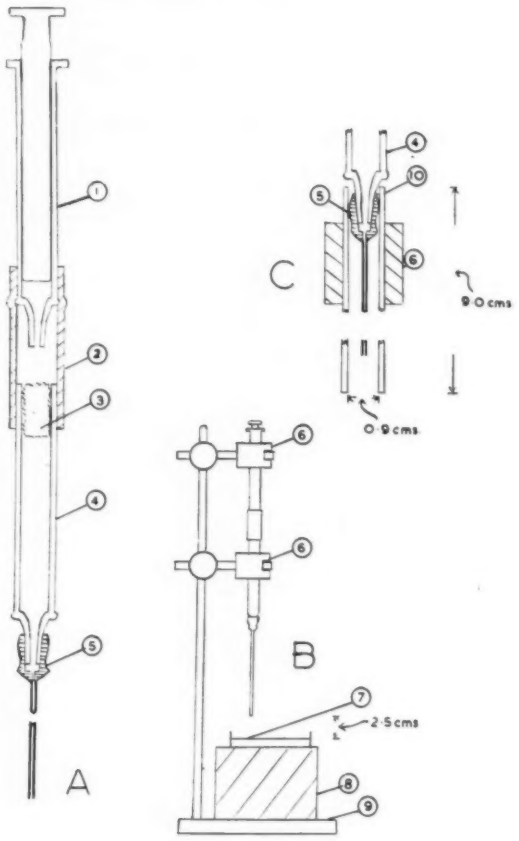

Fig. 1. A. Pipette with controlling syringe. B. As used for plate counts. C. Arrangement of guide tube for filling ampoules.

1. **2 ml. glass syringe.**
2. **Rubber tubing.**
3. **Cotton wool plug.**
4. **Glass syringe barrel with flange removed.**
5. **18 g. x 2½ in. stainless steel hypodermic transfusion needle (luer fitting) ground off square at the tip.**
6. **Clamp.**
7. **Agar plate.**
8. **Wood block.**
9. **Retort stand.**
10. **Glass guide tube.**

TABLE I

Comparison of variation in weight (mg.) of drops of distilled water delivered from supported (A) and unsupported pipettes (B)

	Pipette A			*Pipette B*		
Test No.	*Mean*	*Range per run of 15 drops*	*S.E.* per drop*	*Mean*	*Range per run of 15 drops*	*S.E.* per drop*
1.	21·25	21·1 — 21·4	0·086	21·92	20·6 — 23·0	5·389
2.	21·79	21·6 — 22·0	0·279	21·99	21·0 — 22·8	3·584
3.	21·81	21·5 — 22·2	0·336	22·18	21·3 — 22·8	2·346

*The standard errors per run of 15 drops can be obtained by dividing the S.E.'s per drop by $\sqrt{15}$ i.e. 3·87

the pipette before they are fully formed. It is also considerably less tiring to use for long periods of time. When used with a guide tube (Fig. 1C) for filling ampoules, contamination of the neck and walls of the ampoule with suspension can be avoided.

Construction

The tips and bevels of needles are ground off square on a rotary grindstone and 'finished' on an oil stone. The flanges of the syringe barrel are removed with blunt nosed pliers and any roughness removed with a grindstone. Barrels of the interchangeable type of glass syringe can be purchased separately from the plungers but the glass adapters from transfusion kits used by Wolochow (1959) may be cheaper.

Methods of Use

The plunger of the controlling syringe should be heavily greased with Vaseline so that it will not fall under its own weight. By lowering the plunger with a slightly rotary motion very fine control can be obtained over the rate of drop formation. For accurate work drops should be expelled at a constant rate which should not exceed 40 per minute (Fildes, 1931). After use, the pipettes are detached from the controlling syringe, sterilized in 2 per cent Lysol, and washed, the tips of the needles being rinsed in acetone to remove any grease, and sterilized in tins by autoclaving. Where large numbers of counts are made daily, autoclaving may be unnecessary.

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CORRESPONDENCE

To The Editor,
Laboratory Practice.

DEAR SIR,—In his discussion of the distance of objects in the universe in your October issue, Mr. Phillips does not seem to meet the point raised in your July editorial.

The problem is not one of expression but of comprehension, and while it is true to say that the use of a logarithmic scale provides a convenient picture of cosmic distances, the impact upon the human brain of the figures which he quotes does not, certainly to me, assist visualization. On the contrary, to express the diameter of the earth by the figure 3·9, and then to express the distance of the furthest visible galaxy by 20·8 conveys nothing of cosmic distance to the emotional part of the mind, however easy it may make expression and calculation.

But is visualization of cosmic structure in terms of our common yardsticks desirable? We are all of us tempted, implicitly or explicitly, to reduce scientific data to models which are comprehensible in terms of our everyday experience. Such models may serve purposes which are useful, but any use must necessarily be limited. When we think of 'distance', we think of something which can be measured by measuring rods or mileometers; the danger is not that of failing to comprehend inter-galactic distances, but of failing to admit (to ourselves) that such distances cannot be measured by such mechanical methods even in principle, and that they have little in common with such a statement as 'My desk is 7 ft. 8 in. from the door of my office', or even that 'The equatorial diameter of the earth is 7926·88 miles'.

Custom, familiarity and training enable us to accept cosmic distances, as we can accept intra-nuclear distances, and cosmic concepts (for instance the hypothesis of continuous creation) as we can structural concepts (the square of a probability function), but an attempt to express cosmic distances on a scale of numbers (0-21) which is familiar to us from our everyday experience, does not seem to serve a useful purpose. It is admittedly easier to carry out some calculations with the use of logarithms, but I doubt whether many people find logarithms an aid to visualization in spite of the 'widespread use of log graph paper in industry and commerce'.

The grave disadvantage of Mr. Phillips proposed scale seems to me to be this. For those who are accustomed to it, the expression of numbers in logarithmic form holds no terrors and no secrets, though the use of a numerical scale without quoting the logarithmic base may hold real dangers. But for those who are not so accustomed, and who wish to learn something of the present state of our comprehension of the universe, the use of the figures '3·9', '20·8' may convey a linear ratio which such people will find impossible to convert to logarithmic terms. Not only this, but the danger of a miscomprehension of the 'meaning' of the numbers, may itself be less than the danger of a failure to realize that cosmic duration in time and extension in space are qualitatively different from the 'real' times and distances of our everyday life.

Yours faithfully,
C. J. MANDLEBERG,
Technical Superintendent.

Harbens Ltd.
Parkside Mills,
Golborne, nr. Warrington.

£1,500 Offered for Science Study

H. B. Selby & Co. Pty. Ltd., Australia, distributors of E-MIL volumetric glassware, have announced the foundation of the Selby Fellowship. It is administered by the Australian Academy of Science, located at Canberra, A.C.T. and correspondence should be addressed to the Secretary.

This Fellowship is open to scientists at doctorate level, from any country of the world, in any field of science, for one year at any Australian University or Research Establishment. Nominations for the Fellowship close in Canberra on November 1, each year.

An emolument of £1,500 (Australian) will be paid to the successful applicant each year, and his return fare to and from Australia will be met by the company.

ARTICLES

THE LABORATORY ESTIMATION OF CURARE—LIKE ACTIVITY IN NATURAL AND SYNTHETIC PRODUCTS

by J. J. Lewis and T. C. Muir

Department of Materia Medica and Therapeutics, Glasgow University.

Part II

Methods Employed for the Laboratory Evaluation of Neuromuscular Blocking Agents

The methods described are those used routinely in these laboratories. Other methods are referred to, but no attempt has been made to describe all the methods which have been used by numerous investigators to assay these classes of compounds.

The clinician must ultimately determine the criteria for the ideal muscle relaxant. Collier[29] has considered this problem and though no ideal drug has yet been found it will almost certainly resemble tubocurarine rather than decamethonium.

Three main groups of animals are used, namely birds, amphibians and mammals and, though useful, the results obtained do not necessarily give a reliable forecast of the type of activity or potency of a new compound in man and often only clinical trials[59] and tests on human volunteers will do this.

Quantitative Methods

The Isolated Frog Rectus Abdominis Muscle Preparation.—The method used is essentially that described by Burn.[30] It can be used to assay competitive and depolarizing muscle relaxants. Tubocurarine inhibits acetylcholine-induced contractions of the frog rectus abdominis muscle and this forms the basis of a method for estimating the potency of the former, while the similarity between acetylcholine and decamethonium in producing contractions of the rectus has already been referred to. The rectus can also be used to estimate the potency and mode of action of new synthetic compounds of either class.

Method: An adult frog is stunned by a blow on the head, decapitated and pithed. It is then laid on its back on a cork-covered dissecting board and pinned down. The skin of the abdomen is cut away to expose the rectus muscle which is dissected from its insertion into the pelvic girdle to the point of insertion into the cartilage of the pectoral girdle. The rectus muscle is freed by blunt dissection from the underlying connective tissues, removed from the frog and suspended in an organ bath of 20 ml. capacity by means of two threads tied to either end of the muscle. A loop is made in the thread at one end in order to fix the muscle to the bent wire in the base of the bath and a long thread is left at the other end. This is tied to a modified frontal point writing lever with a magnification of eight to ten times. The bath (Fig. 11) is filled with 20 ml. of oxygenated frog Ringer's solution at room temperature. Drugs are administered by adding them to the bath from a 1 ml. graduated tuberculin syringe. All drugs are dissolved in frog Ringer's solution. The concentration of acetylcholine used to produce contractions of the muscle is of the order of 0·10 to 0·20 μg. per ml.

Two uniform submaximal contractions to the same dose of acetylcholine are obtained before the effects of the drugs under investigation are studied. A suitable time interval between each dose of acetylcholine is usually about six minutes; the contractions are recorded for 90 seconds but in the case of decamethonium and other synthetic depolarizing drugs sufficient time must be allowed for the muscle to regain its original length. This takes about 30 minutes and two or three minutes are allowed for recording the contractions. The time cycle for a particular experiment having been established, it must be rigidly adhered to. Before the next addition of the drug under test, sufficient time must be allowed for the muscle to regain its original length and generally several additions of acetylcholine or decamethonium to the bath are required for complete recovery.

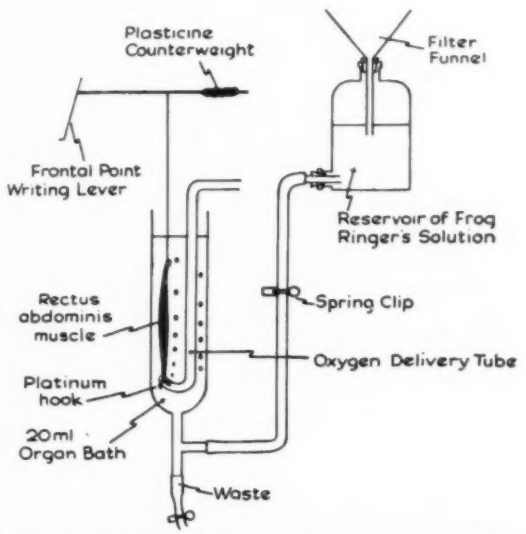


Fig. 11. Diagram of the apparatus used for experiments upon the isolated frog rectus abdominis muscle.

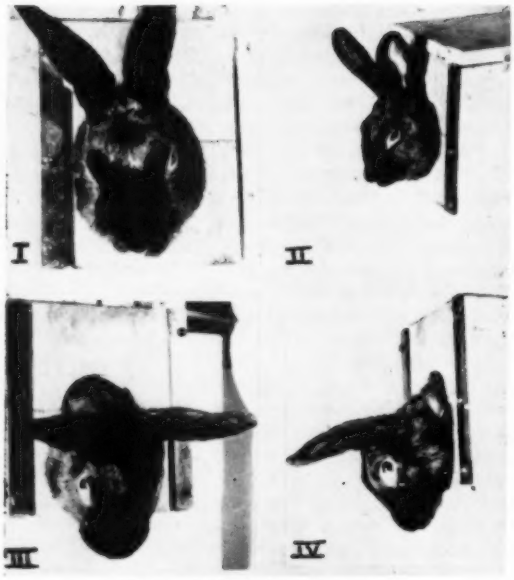


Fig. 12. Rabbit head drop test.
I and II, before infusion of drug.
III and IV, after infusion of drug.

The Rabbit Head Drop Method

The basis of this method was outlined by Bennett,[31] Holaday[32] and Dutcher[33] and several investigators, including Dutta and McIntosh,[41] have since modified the procedure. That described and used in these laboratories is the modification described by Varney, Linegar and Holaday.[34]

Rabbits of either sex weighing between 1·5 and 3·0 kg. and not having been previously used for experimental purposes are suitable. A group consisting of nine animals for each drug under investigation is chosen to permit statistical analysis. The rabbits are placed in individual wooden bleeding boxes with the head protruding through the opening at the front (Fig. 12). The animals are allowed to settle quietly in the box for some time before the experiment is begun. The drugs under test are diluted with normal saline. The concentration depends on the potency of the drug used. A suitable means of injecting the drugs is by using a Palmer's slow infusion apparatus by which a dose can be administered from a 50 ml. all glass syringe with a concentric nozzle which is fitted into the apparatus and connected by means of rubber tubing to a hypodermic needle. After ensuring that all air bubbles have been eliminated from both syringe and tubing, the needle is inserted into a marginal ear vein. The reading on the syringe is noted and the apparatus switched on. The rabbit remains quiet until a few minutes before the end-point is reached when there is usually a brief period of restlessness. Soon after this the rabbit's head begins to fall, although it can still raise it voluntarily. Intravenous infusion is stopped only when the neck muscles are fully relaxed and toneless and a light tap on the muzzle produces no raising of the animal's head. At this point the reading of the syringe is again noted. The difference between the two readings gives the volume of solution injected. The dose required for head drop is calculated and expressed in mg. per kg. of body weight as the head drop dose or H.D.D.

This method can be adapted to indicate the type of drug being used. Neostigmine (0·1 mg. per kg.) injected subcutaneously into the rabbit 15 minutes prior to the intravenous infusion of tubocurarine increases the head drop dose significantly, indicating the efficiency of this agent as an antidote. The ratio head drop dose for the neostigmine-treated animals/head drop dose for the untreated animals can be determined and if this exceeds unity it shows antagonism by neostigmine (therefore, a tubocurarine-like effect) and if less than unity, potentiation and, therefore, a decamethonium-like action.

This method of assay is limited to compounds having a fairly rapid onset of action and having a duration comparable to that of tubocurarine.

The Isolated Rat Phrenic Nerve Diaphragm Preparation.—The method used is essentially that described by Bülbring.[35] Adult rats of either sex are killed by a sharp blow on the head, the throats cut and the blood allowed to drain out. The rat is now laid on its back on a cork-covered dissecting board to which it is pinned. The skin over the chest is removed and the thorax opened along the right side of the sternum. The frontal portion of the right thoracic wall is removed, the mediastinum behind the sternum severed and a cut made just above the frontal insertion of the diaphragm, care being taken not to damage the phrenic nerve which is sometimes attached to the ribs. The frontal part of the left thoracic wall is then removed and the phrenic nerve exposed. Both lobes of the left lung are removed and the left phrenic nerve carefully freed from fat and other tissues. The left abdominal muscles are cut along the costal margin. Holding the last rib with a pair of forceps, a segment of the diaphragm can now be dissected out and two converging cuts made through the ribs towards the tendinous part of the diaphragm and parallel to the direction of its muscle fibres. The cuts are made about 5 mm. to the right and 5 mm. to the left of the point where the phrenic nerve enters the diaphragm. The strip of diaphragm is now dissected out beyond its tendinous part with about 5 cm. of the phrenic nerve attached to it. The preparation is fan shaped, approximately 2 mm. wide at the tendinous end and 20 mm. wide at the costal margin. The costal margin of the diaphragm segment is now fixed to a J-shaped glass rod by means of platinum wires and a thread tied round the tendinous end. The preparation is set up in a 100 ml. organ bath (Fig. 13) containing double glucose Tyrode's solution. The J-piece holds the costal margin of the segment in position at the bottom of the organ bath, while the thread tied at the tendinous end is fixed to a light isotonic heart lever writing on a smoked drum surface. Tyrode's solution containing double the usual

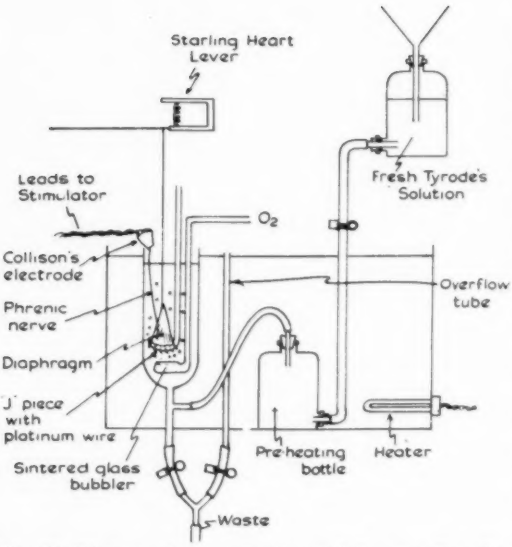


Fig. 13. Diagram of the apparatus used for recording the contractions of the kitten or rat diaphragm produced by electrical stimulation of the phrenic nerve.

amount of glucose is supplied to the bath from a reservoir *via* the heating coils, the temperature of the bath can be maintained thermostatically at 29 ± 0·5° C. A sintered glass distribution tube is fixed at the bottom of the bath to provide a vigorous supply of oxygen which aerates and mixes the bath fluid. A thread is now tied to the cut end of the phrenic nerve and using a fine needle, approximately 1 cm. of the phrenic nerve is drawn into a fluid electrode.[36] The electrode containing the nerve is filled with double glucose Tyrode's solution and the end of the socket holding the electrode sealed off with soft paraffin. By this arrangement the fluid surrounding the nerve at the point of stimulation is not in electrical contact with the fluid surrounding the muscle in the bath. The nerve is left sufficiently slack to allow for any movement caused by the contraction of the diaphragm. Single square-wave impulses are applied to the nerve using a Dobbie McInnes square-wave generator at a frequency of 6 to 10 per minute at 8 to12 volts, the pulse width being 0·5 to 2 msec. In any one experiment values for frequency, voltage and pulse width must be kept constant.

Drugs (in solution in double glucose Tyrode's solution) are added to the bath from a 1 ml. graduated tuberculin syringe and are allowed to act for a fixed time (three minutes is a suitable period) after which the Tyrode's solution in the bath is changed. There is an interval of about 15 minutes between the addition of one dose of the drug and the addition of the next, enabling the Tyrode's solution to be changed several times.

This preparation was found by West[37] in 1947 to give satisfactory results over longer periods if the bath temperature was lowered from 37° C. to 20° C. He also noted that the addition of potassium chloride accelerated the rate of recovery of the preparation. Zoha[38] also found that the magnitude of the contraction remained satisfactory when the bath temperature fell from 37° to 20° C. but normal recovery was achieved without the addition of potassium chloride.

Chou[39] who used this preparation to assay curare-like substances allowed the solution of tubocurarine to remain in the bath for three minutes. This is the optimal period in practice, for if the drug is allowed to produce its maximal effect, the time required to wash it off the receptors reduces the number of comparisons which can be made on the one preparation.

A serious disadvantage of this preparation is the comparative insensitivity to decamethonium and other depolarizing muscle relaxants. Wien,[40] comparing the relative potencies of tubocurarine and similar acting muscle relaxants, reported that using the rabbit phrenic nerve diaphragm preparation gallamine had a potency equal to that of tubocurarine but it had one-fifth of the potency of tubocurarine on the kitten diaphragm and less than one-hundredth the potency of tubocurarine on the rat diaphragm.

The kitten phrenic nerve diaphragm preparation may also be used in conjunction with the rat phrenic nerve diaphragm preparation. Kittens of either sex weighing between 200 and 400 g. are generally preferred. The method used is essentially that described for the rat diaphragm. For stimulation, a current of 10 volts at a frequency of eight per minute, pulse width 1·0 to 3·0 msec. are found to be suitable. This preparation is claimed to be as satisfactory as the rat phrenic nerve diaphragm preparation by several investigators but Bülbring[35] found that even with single shocks given at the slow rate of five per minute, the muscle twitches slowly decline in magnitude.

The Cat Gastrocnemius Muscle Sciatic-nerve Preparation.—This preparation is used to investigate the qualitative effects of neuromuscular blocking agents (for example, the nature of the neuromuscular block produced, the duration of block and other characteristic features) and also semi-quantitatively to compare the potency of a new muscle relaxant with that of tubocurarine or decamethonium.

Cats of either sex, weighing between 2·0 and 5·0 kg. are anaesthetized by an intraperitoneal injection of sodium pentobarbitone (60 mg. per kg.) or intravenous chloralose (approximately 8 ml. per kg. of a 1 per cent solution of chloralose in distilled water is usually sufficient). Ether can be used to induce surgical anaesthesia which is maintained by intravenous injection of chloralose when the dissection is complete. When anaesthesia is sufficiently deep, the external jugular vein and the trachea are cannulated. The anesthetized cat is laid on its back on an operating table and the legs are secured by means of string ties, the head being extended by passing a thread through the skin at the apex of the lower jaw. The skin covering the neck is now cut away from the sternum to the apex of the mandible, the fascia

covering the trachea divided at the midline and the blunt point of an aneurysm needle passed between the muscles of the neck and thence round the trachea. A strong linen thread is passed around the trachea and a transverse incision made in the latter by a scalpel. The cut edge of the partially severed trachea is now held in a pair of blunt forceps and a tracheal cannula inserted and tied securely in place. This procedure is carried out as a precautionary measure so that if respiratory failure occurs artificial respiration can be given. The amount of air entering and leaving the cannula can be controlled by an adjustable sleeve.

One of the external jugular veins is now cannulated; to do this the skin of the left anterolateral part of the neck is removed and the external jugular vein exposed. The fascia covering the vein is carefully removed and a thread tied around the cephalad end while a bulldog clip is put on the vein on the cardiac aspect. A small transverse cut is now made on the dilated vein by means of a pair of sharp pointed iris scissors and a vein cannula filled with heparin solution inserted through the incision, the pointed end being towards the heart. The cannula is connected by means of rubber tubing to a 50 ml. burette containing normal saline. Care is taken to eliminate all air bubbles from the system. The saline from the burette must run freely into the vein.

Having completed the cannulation of the trachea and the external jugular vein, one leg is prepared for indirect stimulation of the gastrocnemius muscle *via* the sciatic nerve. The gastrocnemius muscle is partially dissected free from the surrounding tissues and the Achilles tendon severed at a point near to its insertion in the calcaneus. A strong linen thread is tied around the free end of the tendon. The leg is held with its long axis perpendicular to the operating table and fixed rigidly by means of two clamps, one at the knee joint and the other at the ankle as shown in Fig. 14. The thread tied to the Achilles tendon is led over pulleys and attached to a Sherrington myograph lever, the writing point of which is adjusted so as to record the contractions of the muscle on a moving smoked surface. By means of an incision made through the skin covering the lateral aspect of the thigh, the sciatic nerve is exposed between the hamstring muscles. It is held firmly by artery forceps and a pair of shielded platinum electrodes placed around the nerve distal to the forceps. Stimulation of the nerve is carried out using a Dobbie McInnes stimulator at a frequency of four to eight per minute, at 10 to 20 volts, the pulse width being 2·0 to 3·0 msec. These figures are arbitrary values and may vary from experiment to experiment but they must remain fixed for any one experiment. The tension placed upon the muscle (which is of the order 0·2 to 0·3 kg.) must also remain constant. During the course of the experiment the tension alters due to the contraction of the muscle in response to electrical stimulation, and while values from experiment to experiment may vary it usually remains about 0·6 to 0·8 kg. Drugs are administered in the form of solutions in normal saline by means of a 1 ml. graduated tuberculin syringe, injection being made into the rubber tubing connecting the burette and the jugular vein cannula. After each injection the drug is washed in by a suitable volume (3 ml.) of saline.

The Estimation of Curarizing Potency using Mice.—Two quantitative methods have been described using this species. Skinner and Young[42] described in 1947 a method employing a rotating cylinder, administering the drugs under test subcutaneously. The mice were placed in a rotating cylinder and those falling away

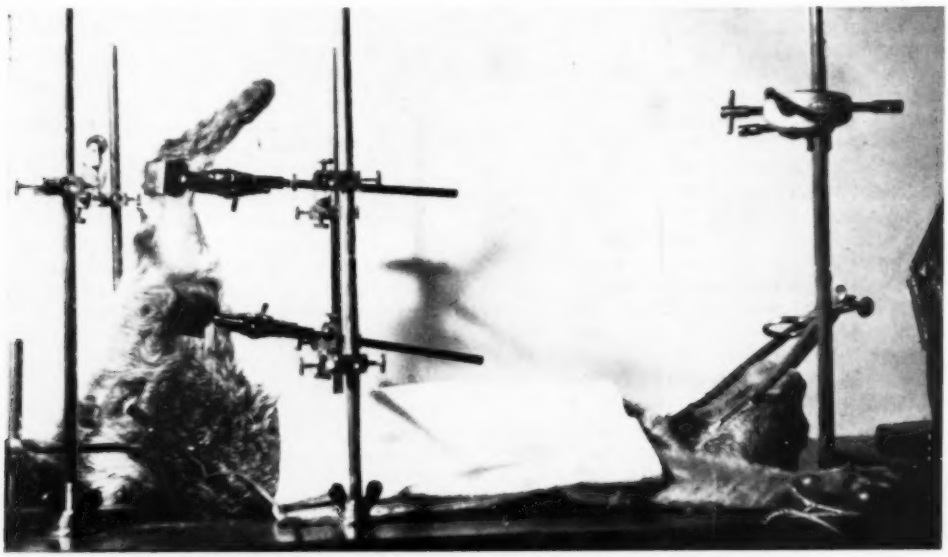
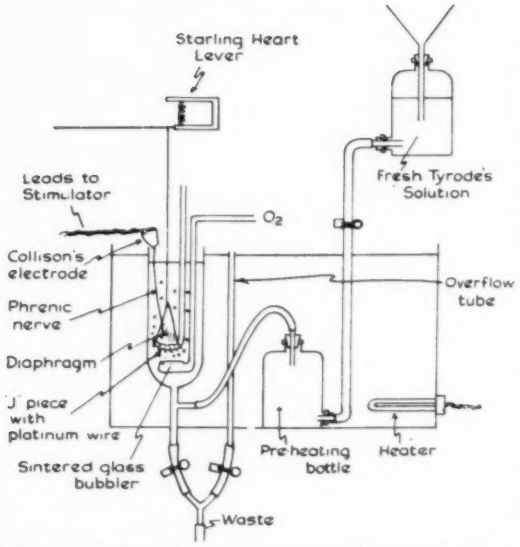


Fig. 14. The cat gastrocnemius muscle-sciatic nerve preparation.



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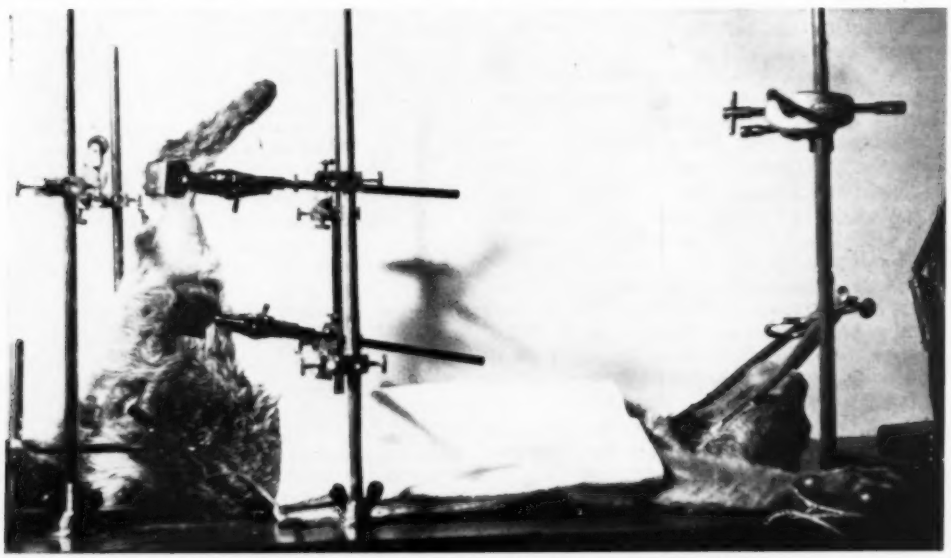

Fig. 14. The cat gastrocnemius muscle-sciatic nerve preparation.

within a fixed period of time were considered positive reactors. Statistical methods were employed to express the results in terms of the 50 per cent effective dose or ED 50.

Pick and Richards[43] also described a quantitative method using mice which had been previously injected with morphine sulphate. The abolition of tail erection in mice by tubocurarine is the basis of this method, in which the drugs under test are administered intraperitoneally.

Collier and his colleagues[44] using a method resembling that of Skinner and Young[42] have estimated the potency of tubocurarine in mice and also that of tubocurarine dimethyl ether in rats. Collier administered drugs intravenously and so eliminated the variation in response introduced by subcutaneous and intraperitoneal injections due to differing rates of absorption from the site of injection. Furthermore, using the intravenous route of administration it was shown that due to the rapid onset of action of tubocurarine, variation caused by differing rates of elimination of the drug would be reduced to a minimum. In this assay mice are given intravenous injections at a controlled rate and using a serial dilution of the solution to be administered, the volume of drug kept constant in relation to the body weight of the mouse. The animal is observed subsequent to the beginning of administration and turned on its back from time to time. The loss of the righting reflex within a given time is taken as a positive result. A further modification was made by Collier using a rotating drum in an endeavour to obtain greater accuracy and to overcome the variation in subjective judgment liable to occur when the previous method is used. After intravenous injection of the drug, the mouse is placed on wire mesh on the upper surface of a rotating drum the animal facing against its direction of movement. Those mice unable to retain their hold on the moving surface fall off and this is taken as a positive result. This method has been found by Collier to give a positive reaction at a lower dosage level than is required to abolish the righting reflex.

A method used routinely in these laboratories is one originally used by Thomson[45] for the assay of insulin in mice. Solutions of drugs are injected intraperitoneally into mice of either sex weighing from 20 to 30 g. Groups of mice are injected at different dose levels and placed on a fine-mesh wire screen inclined at an angle of 50° to the horizontal. Those mice which developed a typical skeletal muscle paralysis and abruptly slid off the screen within 30 minutes are considered to have shown a positive reaction. The dose at which five out of 10 mice slide off the screen is taken to be the approximate median paralysing dose (PD 50) expressed in mg. per kg. of the body weight. In order to determine the approximate median lethal dose (LD 50) the dose at which five out of 10 mice in a particular group die within half an hour is taken and expressed in terms of mg. per kg. of the body weight. The results were calculated using statistical methods.

These tests are fairly easily carried out and can give useful information regarding new compounds. They may be criticized in that the response produced, namely the loss of righting reflex, or the inability to remain on a rotating drum or inclined plane may also be produced by other drugs (for example morphine or the barbiturates) and results obtained from these tests should be correlated with those obtained from tests on other species.

(To be continued)

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Some Applications of E.D.T.A.

At a recent Ordinary Meeting of the Midlands Section of the Society for Analytical Chemistry under the chairmanship of Dr. H. C. Smith, F.R.I.C., a discussion on 'Some Applications of E.D.T.A.' was opened by T. S. West, B.Sc., Ph.D., A.R.I.C. (Birmingham University); J. Blenkin, B.Sc., (Dunlop); and C. A. Johnson, B.Pharm., B.Sc., F.P.S., A.R.I.C. (Boots).

Dr. West discussed recent advances which had been made in the technique of complexometric analysis. The subject matter ranged over new complexones, indicators, methods of physico-chemical end-point detection, masking procedures, etc. Recent trends were examined and some comments made on possible developments in the near future.

Mr. Blenkin gave a brief description of the development of some methods incorporating E.D.T.A. titrimetry for the analysis of the ash from compounded rubber.

These methods had particular reference to:

(*a*) The determination of barium sulphate by solution in ammonium E.D.T.A. after pre-treatment of the sulphate.

(*b*) The determination of strontium in the presence of zinc, using differential pH techniques and ion-exchange resins.

(*c*) The determination of iron, aluminium and magnesium in silicates after fusion in sodium hydroxide.

Mr. Johnson said that during the past few years E.D.T.A. had been used increasingly for routine analytical control in the pharmaceutical industry. Some of the types of problem occurring in this field were reviewed and a somewhat more detailed account was given of the analysis for aluminium. The use of complexometric methods for the determination of alkaloids and of sulphate were considered. Finally some attempt was made to assess the contribution which E.D.T.A. had so far made to routine control analysis.

HIDDEN TREASURE

by Prof. S. Tolansky, F.R.S.

Royal Holloway College, Egham, Surrey (London University)

IN these current days of mass produced instruments it is not sufficiently widely recognized that there must almost certainly exist in our University laboratories a veritable hidden treasure, a hoard of useful, high quality, research instruments. These are doubtless hidden away at the back of stores and cupboards, their existence hardly recalled and their real value often unrecognized, yet they can be of considerable potential use if put into the hands of the right people. These existing hoards have undoubtedly arisen as a result of inevitable changes in the holders of professorial chairs, as the years go on. It is for instance only to be expected that if an electronics specialist succeeds an optics expert, he is unlikely to find any use for the specialized optical material he will find. In due course optical research will be discontinued, and what happens? The optical equipment, which truth to tell is often not fully appreciated, is stored in boxes or wrapped in cotton wool, laid by in an obscure cupboard and then more or less forgotten. Indeed the tragedy is complete when the faithful laboratory steward retires, for then no one even remembers about the hidden store.

Such stored equipment is by no means always obsolete, indeed far from it. It is stored in the first instance only because its character is completely foreign to the new field of work and it is more often than not overlooked through a failure to recognize its active potentialities in other laboratories. It is more than probable that there must be lying latent in our University laboratories appreciable quantities of *high quality* material, doubtless years old, yet still eminently usable for serious scientific research. Not all research is carried on with nuclear reactors or space rockets!

It is suggested that some central organization should make a national effort to explore the situation aiming at bringing to light any such hidden equipment with a view to exploiting its use by a co-operative system of extended loans. The conjecture put forward here as to the existence of such a hoard, on a national scale, is not so absurd as some may imagine. From my own knowledge I can quote instances which bear this out. For example, in about 1930 or so, the Bursar at the University of Manchester happened to mention to the then professor of physics (Sir Lawrence Bragg) that for years there had been lying in his safe a wooden box, sent over from the Physics Department by Sir Ernest Rutherford, who had been professor of physics at Manchester during 1911-19. The box was opened and found to contain a large 21 ft., fine-quality, speculum concave grating, inscribed as a personal gift from Rowland to Schuster, who held the chair at Manchester before Rutherford. This grating was installed in a fine housing by Sir Lawrence and for a number of years some excellent research was carried out with it, as I myself can testify. Not only were purely scientific spectroscopic problems studied, but even in fact a minor study of interest to the military, in that the light emission from military searchlight arcs was studied with a view to improving their efficiency. This was certainly no obsolete spectroscopic instrument, despite the fact that it had lain hidden for some 20 years. It may actually be back in store now, owing to local changes of interest.

Then again, let me quote further instances out of my own experience, in slighter vein. In 1932, I found at Imperial College wrapped in cotton wool, in a dusty old cupboard, two magnificent large prisms which had clearly been there some years. I was able to trace the fact that these had belonged to Sir William Crookes, years back, and with them I made an excellent spectrograph, ideally suited to hyperfine structure researches I was then engaged upon. Or again, in 1935, Mr. Green (a supreme artist in the craft of optical surfacing) the expert at Adam Hilger Ltd., made for me a unique Lummer plate interferometer. The quality of this is such, that it is my opinion that it could not be equalled today by any optical instrument maker. It was not equalled by Mr. Green himself! I used this instrument frequently until 1945, but my optical interests underwent a change and from then on it lay dormant for some years, carefully boxed. I ultimately arranged the transfer of this to Prof. Ingold of University College, who now exploits it actively.

Now this exploitation only came about through personal co-operation, and the intense feeling on my part that so unique an instrument must not lie boxed up. It might easily have happened under other circumstances that the instrument might indeed have lain dormant.

Mention of this Lummer plate interferometer brings forcefully to my mind the sad fate of the very *first* Lummer plate ever made. This following story is undoubtedly true, for it was told me by F. Paschen (I worked under him for a year during 1930-1) who was at the time of telling President of the Physikalisch-Technische-Reichsanstalt in Berlin, and certainly Paschen was not given or exaggeration or fantasy. Lummer was at the Physikalisch-Technische-Reichsanstalt in 1897 where he there constructed his first glass plate interferometer, to become the celebrated Lummer plate. This instrument was, in due course, stored in a cupboard, and then, as so often, completely forgotten. Some 25 years later a research worker was found using an old scratched block of glass as a paper weight. Someone commented on the fact that the glass block had carefully ground edges. Inspection identified it as the very first Lummer plate! ! For indeed the known dimensions were found scratched on the side, Lummer

(*Concluded on page* 387)

A Mobile Vacuum Unit for the Organic Laboratory

by Andrew Hislop

Senior Technician, Chemistry Department, The University of Glasgow

THE purification of liquid organic compounds is frequently carried out by distillation under reduced pressure. A vacuum range of 0·05-0·005 mm. Hg. obtainable from commercial single stage pumps (e.g. Edwards Speedivac) has been required in our laboratories. The advantages of having a mobile unit giving this vacuum need not be discussed here. However, construction of such a unit in which common sources of trouble have been eliminated, is not without its difficulties and we wish to record here the details of a design which is a summation of our experience with many of these trolley units, both of the commercial and laboratory-built types. In addition certain new features have been incorporated into a composite unit which has been giving satisfactory performance in the laboratory. Our main concern was to eliminate the following sources of trouble generally inherent in trolley pump design, viz. excessive vibration, mercury spillage and carry-over from the Vacustat and a complaint applicable to all pumps—oil suck-back due to over rapid or careless shut-off technique—a common failing of research workers everywhere.

A trolley was constructed of Handy Angle so that the top came up to the level of the laboratory bench with the frame mounted on light duty castors, the top being made from half-inch blockboard and the cover from one-eighth inch plywood. Formica, impervious to most organic solvents, was glued to the surfaces. Foam rubber strips were placed between the wooden top and the Handy Angle framework of the trolley. Apertures were cut in the top and cover to house the vacuum line and permit access to the stopcocks and the cover hinged to the top was thus securely held by two spring clips when closed, thus giving protection to the vacuum line and making it readily accessible. A two-inch aluminium angle was screwed around the top of the trolley enclosing the raw edges of the blockboard. A foam rubber pad was placed under the vacuum pump motor. The pump unit was then mounted on the frame with rubber strips sandwiched between the bed plate and the Handy Angle frame. When securely bolted it was possible to balance a coin edgewise on the top when the pump was running. (There are commercial anti-vibration mounts on the market but at the time of construction foam rubber was more readily available.)

The vacuum line (Fig. 1 and 2) was made of Pyrex glass and constructed in four parts thus simplifying cleaning and replacement in case of breakage. A tee-shaped double pump pattern stopcock of 10 mm. bore was placed between the pump and the vacuum line. One end of the stopcock is open to atmosphere the other end is joined to the Vacustat via a ball and socket joint (Fig. 3). Using this stopcock the vacuum line can be left under vacuum whilst the pump is open to atmosphere. Around the neck of the stopcock a strip of brass was bent extending for half an inch to a brass roller and was screwed to the neck with the roller directly above the centre of the 10 mm. hole in the stopcock head. A micro-switch wired push to break was fastened to a bracket and introduced between the main electricity supply and the pump motor. When the stopcock is in the position of open to air, the switch bracket is screwed

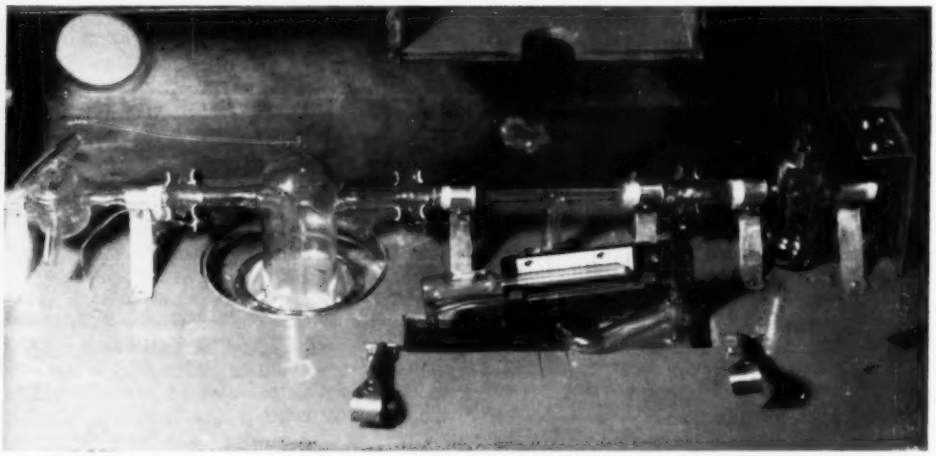

Fig. 1.

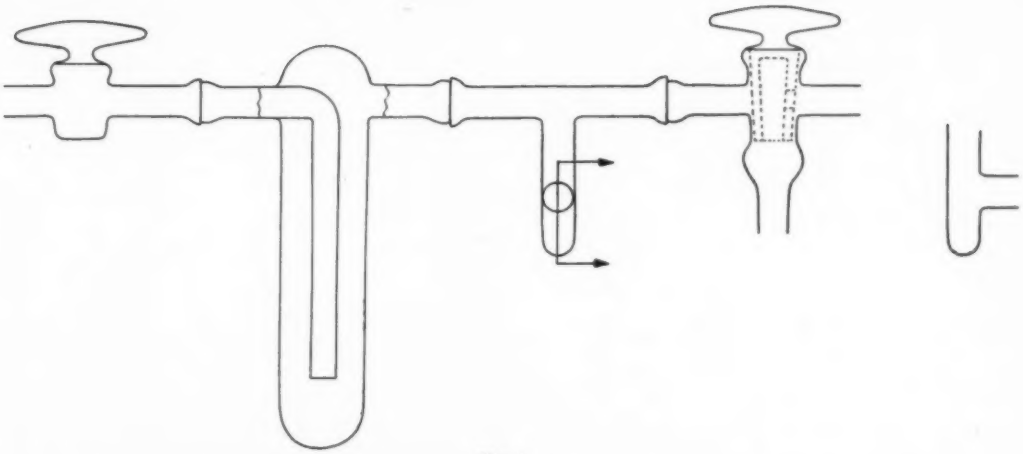

Fig. 2.

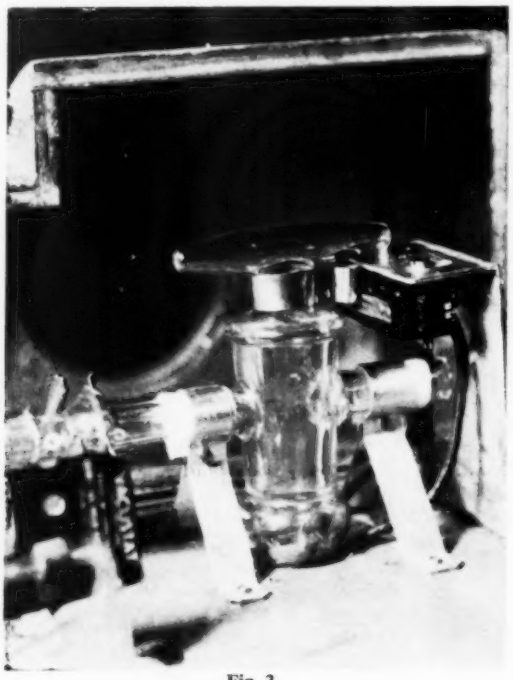

Fig. 3.

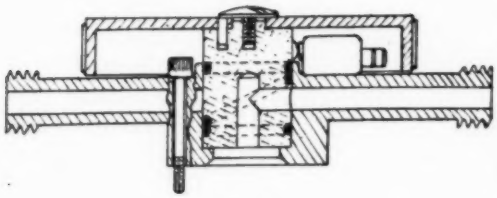

Fig. 4.

to the trolley top with the spring contact arm pressing against the roller. In this position the circuit is open and the pump motor off. By rotating the stopcock a few degrees to left or right the roller is removed from the contact arm of the micro switch, the circuit is closed and the oil pump brought into action. Turning the stopcock head through 180° brings the main vacuum line into operation. It will be seen that as the 10 mm. hole is larger than the contact area of the roller, air can be admitted to the vacuum pump some seconds before the motor is switched off, thus eliminating the suckback of oil from the vacuum pump into the vacuum line. This device automatically ensures that the pump cannot be turned off closed to air. Fig. 4 shows the switch stopcock design for a metal system. The rest of the vacuum line can be made in the usual manner using Edwards vacuum unions with O ring seals instead of ball and socket joints, the cold trap being made from stainless steel tubing hard soldered to the vacuum line.

To prevent mercury spilling into the vacuum line and being swept into the vacuum pump the Vacustat (Fig. 5) was built at a lower level than the main vacuum line which was mounted on the trolley top by aluminium

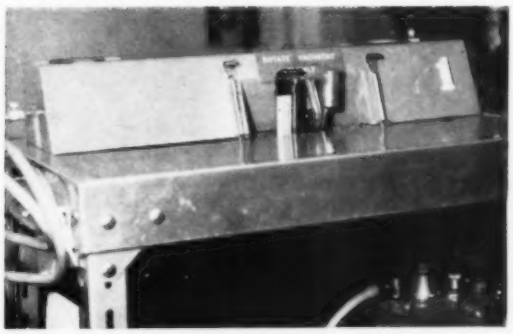

Fig. 5.

brackets (Fig. 1). A small mercury trap was suspended from the vacuum line and the Vacustat cone joint placed half way up. Thus mercury spillage from the Vacustat cannot get into the vacuum line. To return the mercury to the Vacustat it is necessary only to uncouple the Vacustat section and tilt the mercury back into the reservoir. With the Vacustat at rest the reservoir is protected from breakage by a foam rubber nest secured to the underside of the trolley top. It is important when distilling organic liquids that no vapour be allowed to reach the vacuum pump as damage may result and in the past it has been found that insufficient trapping of these vapours can result in a completely seized pump. A mixture of solid carbon dioxide and acetone (—78° C.) is quite efficient for most organic work but it requires a large dewar flask as a reservoir. Still more effective trapping is provided by liquid air (—183° C.) which can be contained in a smaller dewar flask which is more convenient. The cold trap is joined to the Vacustat on one side and a three-way 3 mm. stopcock on the other by a ball and socket joint. By slightly reducing the diameter of the glass tube leading from the three-way stopcock it is possible to slide this section through the neck of the aluminium bracket breaking the vacuum seal between the ball and socket joint and thus simplifying the removal of the cold trap for cleaning purposes. The trap is housed in a metal container and padded with fibre glass sealed off at the top with foam rubber. The container is pushed through a hole in the trolley top; screws passing through the wall of the container secure it in position. At either side of the trolley top brass hooks are screwed: the rubber tubing from the vacuum line and the power cable to the motor can then be wound round to give the trolley a tidy appearance. The holes in the stopcock cover are finished off by splitting a length of rubber tubing, wrapping the tube round the rough edge of the hole and glueing on the underside.

These units have been in continuous use for several months and are providing trouble-free vacuum assemblies with the minimum of maintenance. It is hoped to report on a high-vacuum mobile oil-diffusion unit incorporating several novel features in a subsequent communication.

The author wishes to express his thanks to Prof. R. A. Raphael for encouragement in the preparation of this apparatus and to Miss Sheila Grace (Materia Medica Department) for providing the photographs.

An Electrolytic Respirometer for Insects

by F. P. W. Winteringham, F.R.I.C.

Agricultural Research Council, Pest Infestation Laboratory, Slough, Bucks.

Introduction

Various insect respirometers have been described; e.g. by Crisp and Thorpe (1947), by Smith and Douglas (1949), by Fullmer and Hoskins (1951), and by Schneiderman and Feder (1954). The measurement of rates of oxygen uptake by these techinques required frequent manipulations or observations. Capraro (1953) has briefly described an electrolytic method for measuring the oxygen consumed by small mammals. The animal is enclosed in a sealed chamber and expired carbon dioxide absorbed in alkali. The net reduction in pressure causes the alkali to rise over the surface of a positively charged nickel electrode so that oxygen is electrolytically generated according to the demand of the animal. Since the generation of oxygen in this way follows Faraday's laws of electrolysis the current flowing through the electrolytic unit is a measure of the rate of oxygen consumption. This suggested the development of a similar method for insects in which the current could be automatically and continuously recorded and so preclude the need for continuous observation or manipulation. This paper describes the method and apparatus so developed. They have been in successful use for some five years.

Apparatus

Electrolytic respirometer for large insects or a number of small insects.—Capraro (1953) indicated that increases in the oxygen demand were met in his apparatus by a corresponding increase in the area of the positive electrode covered by the electrolyte. In the insect respirometers described below the currents flowing were so small that the area of immersed electrode was not limiting. Increased oxygen generation was therefore achieved by causing the electrolyte to rise consecutively to the tips of a series of differently raised electrodes, each electrode being maintained at a higher electrode potential than the previous one as indicated in the circuit diagram of Fig. 2.

The electrolysis unit is shown diagrammatically as A—K in Fig. 1. It consists of a Pyrex vessel I closed with a rubber rung K. Through K is inserted a Pyrex tube B which allows the hydrogen generated at the negative electrode F to escape via the soda-lime CO_2-trap A. Through K is also inserted a Pyrex T-piece E which connects to the metabolism chamber L-V′ at the B.10 standard ground glass joint H. The rubber bung C carries the five positive electrodes G1-G5 which are shown in greater detail on the left (inset) of Fig. 1. The electrodes consist of lengths of 20-SWG Nichrome wire filed to a point at the lower ends. The points allow the electrodes to be forced through the bung C in the initial assembly; they also discourage the formation of drops of electrolyte at the lower ends of the electrodes. Short sleeves of Polythene G′ (inset) prevent shorting between the electrodes. The single negative electrode F

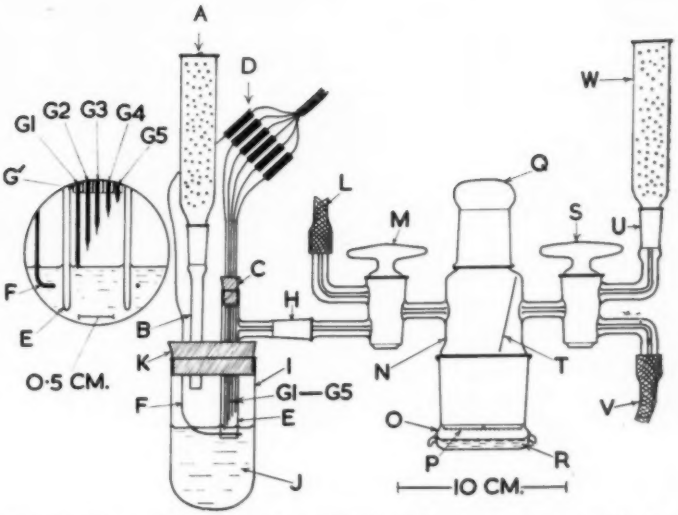

Fig. 1. Large electrolytic respirometer for single large insects or a number of small ones. Arrangement of electrodes is shown in circular inset on the left.

terminates in a loop which encircles the tube E. Hydrogen generated at F escapes at the surface of the electrolyte J while oxygen generated at any of the electrodes G1, G2, etc. effuses into the metabolism chamber N via H. The electrolyte is freshly prepared by dissolving 40 g. of A.R. NaOH in 100 ml. of glass-distilled water. The normal depth of J in I is such that about 1 mm. of the first electrode G1 is immersed while the loop of F is always at least 1 cm. below the surface of the electrolyte at atmospheric pressure. The electrodes are plug-connected at D to a 6-way cable.

The electrical circuit is shown in Fig. 2. The 150-ampere-hour 24-volt accumulator B is connected across the 500-ohm potentiometer R1-R2 through S.1 and milliammeter A (0-100ma.). When F and one or more of the electrodes G1, G2, etc. touch the electrolyte the current flowing through the electrolysis unit is plotted against time by the recording milliammeter R4 (0-5ma.). A recorder drum speed of 1 in. per hr. has been found to be convenient. The decade shunt resistance R3 (0-10,000 ohms.) is adjusted so that the pen of the recorder just remains on the scale when the current demand is maximal (electrolyte at G5 or S.2 closed). The R1/R2 ratio is similarly adjusted so that the maximum current is more than adequate for the maximum likely oxygen demand during the experiment (see below). The indicated values for the electrode resistor chain R5, R6, etc. are such that when R3 is small (e.g. 100 ohms.) compared with R4 (2,870 ohms for the recorders used by the author) the current flowing through the electrolysis unit and the corresponding rate of oxygen generation are approximately doubled as the electrolyte reaches each higher electrode. This means that the recorded current-time curve rises in steps until the oxygen generated electrolytically exceeds or equals the demand. The recorder pen then oscillates between values corresponding to the two electrodes which respectively generate oxygen too quickly or too slowly. Sometimes the generation of oxygen at one particular electrode nearly equals the demand and the oscillations of the recorder pen may have a period of hours. In any case the small unavoidable temperature fluctuations within the apparatus cause small artificial fluctuations in the oxygen demand with time and these have the fortuitous effect of avoiding sharp peaks in the record. This facilitates subsequent measurements of current-time areas by means of a planimeter. With experience it is a simple matter to estimate the mean recorded current per unit time by visual inspection. The potentiometer normally carries a current of 50 ma. while the resistor R5 may carry a current of the order of 100 ma.; the components should have appropriate ratings and R3 and R4 must be accurately known.

The metabolism chamber which contains the respiring insects is shown as L-W in Fig. 1. It consists of a Pyrex chamber N terminating in a B.29 standard ground glass cone at the top and a B.50 cone at the base. A sealed B.29 socket Q closes the chamber at the top and is used for the introduction of the insects. A close-fitting stainless steel gauze circular floor P spring clips just inside the lower lip of the B.50 cone. The flat-bottomed B.50 closed socket O closes the base of the chamber and is normally charged with exactly 5 ml. of aqueous NaOH (R) as prepared for the electrolysis unit. This solution R absorbs expired CO_2 and maintains a constant relative humidity of about 50 per cent within the chamber at room temperatures. The 2-way tap M connects the metabolism chamber to the electrolysis unit or to a small diaphragm pump via L and a gas-flow gauge (not shown). The pump may be used to draw CO_2-free air through the chamber via S and the soda-lime trap W or *cyclo*propane (for anaesthetizing the insects) from a cylinder connected at V via a manometer (not shown). The trap W may be detached for re-charging, etc. at the B.10 joint U. A 10 × 2 cm. card T rests on the floor of the chamber and provides additional walking or resting

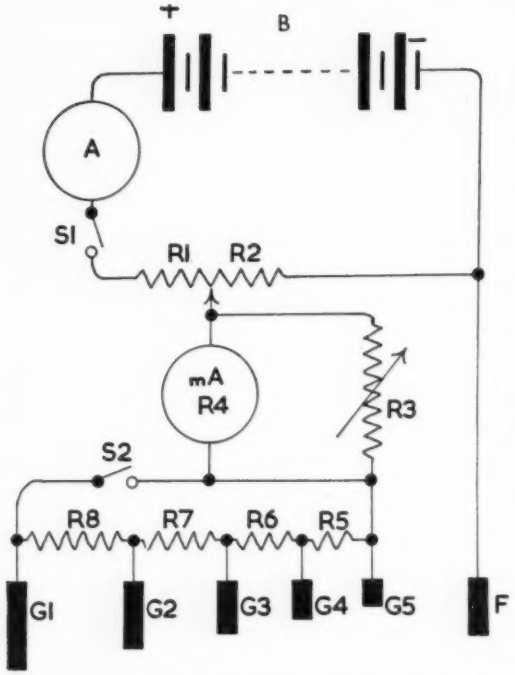

Fig. 2. Circuit diagram showing method of connecting electrodes of large respirometer.

A: Milliammeter, 0-150 *ma.*
B: Accumulator, 24 *volt.*
R1-R2: Potentiometer, 500 *ohms.*
R3: Decade resistance box, 0-10,000 *ohms.*
R4: Recording milliammeter, 0-5 *ma.*, 2,800 *ohms.*
R5: Resistor, 250 *ohms.*
R6: Resistor, 650 *ohms.*
R7: Resistor, 1,000 *ohms.*
R8: Resistor, 2,000 *ohms.*
G1-G5: Anodes.
F: Cathode.

When used in conjunction with the small respirometer (See Fig. 3 and text) a single anode (C of Fig. 3) is used equivalent to G1 only.

surface for the insects. Two assemblies of the type shown in Fig. 1. are enclosed in a cabinet which may be maintained at any constant temperature within the range 25-40°C. ± 0·5°C. and which is provided with an efficient internal air circulation. Taps M and S are remotely controlled to minimize the need for opening the glass door of the cabinet and so causing large temperature fluctuations during an experiment. The total effective volume of the metabolism chamber connected to the electrolysis unit must be known and is approx. 185 ml for the apparatus shown in Fig. 1.

Electrolytic respirometer for single small insects with provision for treatment in situ.—The sensitivity of the respirometer shown in Fig. 1 required the use of several small insects (e.g. ten or more adult houseflies) for the best results. An observed change in the total oxygen consumption could therefore be due to a similar change in all the insects or to a larger change in fewer of the insects. The respirometer shown in Fig. 3 was designed for single insects and thus enabled observed oxygen consumption to be related to the condition and behaviour of the one insect.

The electrolytic cell and metabolism chamber are combined in a single unit shown as A-H in Fig. 3. The electrolytic cell consists of a Pyrex U-tube D. Hydrogen generated at the negative electrode B escapes via the soda-lime CO_2-trap A. Oxygen generated at C effuses into the metabolism chamber H via the capillary F. The tap G allows the internal pressure of the apparatus to be equilibrated with that of the atmosphere. Rubber bungs carry the 20-S.W.G. Nichrome wire electrodes B and C the lower points of which are immersed to a depth of about 1 cm. and 2 mm. respectively in the electrolyte E. The electrolyte is prepared as described for the larger respirometer.

The electrical circuit is the same as that shown in Fig. 2 except that the single positive electrode C of Fig. 3 is substituted for G1 in Fig. 2 and electrodes G2, G3, G4 and G5 are disconnected. The negative electrode B of Fig. 3 is shown as F in Fig. 2. It will be seen that this arrangement does not provide for the automatic adjustment of the electrolysis current according to the oxygen demand. Instead, the potentio-

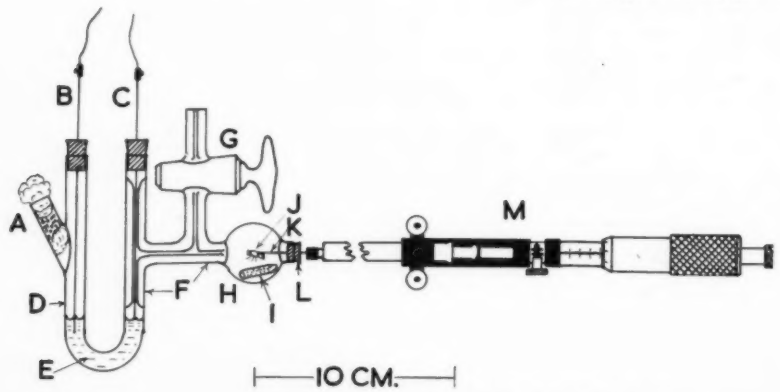

Fig. 3. Small electrolytic respirometer for single insects with provision for treatment during respiration measurements.

meter R1-R2 of Fig. 2 is periodically adjusted so that the current flowing through the electrolytic cell is more than adequate for the maximum likely oxygen demand. The recording therefore consists of a series of peaks. When the oxygen demand is met the electrolyte is displaced to a point just below the tip of the electrode C (Fig. 3) and the recorder pen falls to zero. The significance and interpretation of the recorded current-time area is, however, the same as in the case of the larger respirometer (see below). On account of the small unavoidable temperature fluctuations of the apparatus the recording appears not as a series of sharp spikes but as a series of wider peaks or troughs. This fortuitously facilitates the measurement of the current-time areas by means of a planimeter. The mean current over a suitable time interval may be roughly estimated by visual inspection during the recording.

Within the Pyrex metabolism chamber H are two small glass tubes I open at one end which contain small wads of absorbent wool soaked in aqueous NaOH (as used in the larger respirometer). These absorb expired CO_2 and maintain the internal relative humidity at about 50 per cent. Small wire grids at the mouth of each tube preclude any contact between insect and alkali. The insect is confined to the chamber H by the rubber bung L. The insect may move freely within the chamber. Alternatively, it may be desired to treat it during an experiment either by injection or by topical application. For this purpose the bung L carries the fine-taper 27-S.W.G. needle K attached to the Agla micrometer syringe M (Burroughs Wellcome and Co., London). The insect J is then impaled on K by suitable insertion. of the needle at the commencement of the experiment. In the case of the adult housefly the needle is inserted just below the scutellum, the insect facing to the left as illustrated in Fig. 3 and in an upright position. Houseflies periodically injected with aqueous glucose may survive 48 hr. or more under these conditions and up to 3 μl. of liquid may be injected intrathoracically at a time.

The insect may also be tethered to the needle in such a way that measured drops of liquid may be applied to the integument during the experiment. A pair of respirometers of the type shown in Fig. 3 are enclosed in a constant temperature cabinet as described for the larger respirometers. The total effective volume of the respirometer is approx 15 ml.

Experimental Procedure and Calculation of Results

Large respirometer.—The larger respirometer (Fig. 1) is suitable for one to five large insects like the cockroach (*Periplaneta americana*) or 10 to 50 small insects like the housefly (*Musca domestica*). The insects are weighed and treated if required (e.g. by dosing with insecticide) and introduced into the chamber N through Q with M and S open to L and W respectively. A slow stream of CO_2-free air is drawn through the chamber for a few minutes to allow the insects time to recover from the treatment and to assume the temperature of the apparatus. M is then connected to H to ensure that the electrolyte levels in I and E are the same. S is closed and the switch S.1 (Fig. 2) also closed. A mark is made on the recorder drum indicating the time and commencement of the experiment and R_1, R_2 and R_3 adjusted as explained above. At the end of the experiment the electrolyte in E and I (Fig. 1) is rapidly brought to the same level by opening S.1 (Fig. 2) or by closing S.2 (Fig. 2) according to whether the level in E (Fig. 1) is lower or higher than that in I (Fig. 1). Unless this is done the final total oxygen consumption recorded will be in error by the volume represented by the difference in initial and final electrolyte levels in E. Live insects may be recovered by passing anaesthetic through the chamber via M and S, removing Q, etc.

Small respirometer.—With G (Fig. 3) open the insect is introduced into H either free or suitably attached to the syringe at K (see above). A few minutes are allowed for temperature equilibration before closing G and switching on at S.1 (Fig. 2). In the simplified circuit used for this respirometer an occasional adjustment of the R1/R2 ratio only will be necessary during the course of the experiment.

Calculation of results.—From Faraday's laws of electrolysis, the electrochemical equivalent of oxygen, and the gas laws, it follows that:

$$\Delta O/\Delta t = 208{\cdot}6.\ I.\ (R3 + R4)/R3.$$

Where $\Delta O/\Delta t$ is the mean rate of oxygen generation in mm^3 at *S.T.P.* per hour, I is the mean current in milliamperes recorded at D (Fig. 2) over the same period of time and $R3$ and $R4$ are the resistances in ohms of the shunt and recording milliameter respectively. Mean values of I over any interval of time are obtained by dividing the current—time area (measured by planimeter) of the recorder by the time.

Corrections for changes in atmospheric pressure.—The electrolyte of both respirometers is exposed to the pressure of the atmosphere on the one hand and that of the respirometer chamber on the other hand. It follows that if the atmospheric pressure increase during an experiment an excess of oxygen will tend to be generated electrolytically on that account alone until the electrolyte returns to its original level. Similarly a fall in atmospheric pressure will tend to delay or reduce the generation of oxygen until the demand from the respirometer has restored the electrolyte to its original level. Since the partial vapour pressure of the alkali will remain constant at the constant temperature of an experiment it may be deduced from the gas laws that:

$$\delta V = 3{\cdot}59.\ V.\ \delta P/T.$$

where δV is the volume of oxygen in ml. at S.T.P. by which the recorded volume is in error, V is the total effective volume of the respirometer in ml., T is the temperature in degrees Absolute, and δP is the net change (increase or decrease) in atmospheric pressure in cm. of mercury.' For increases in atmospheric pressure δV must be subtracted from the recorded volume of oxygen generated; for decreases in atmospheric pressure δV must be added. Changes in barometric pressure over particular time intervals (e.g. one

hour) are obtained from a recording barograph mounted near the respirometers.

Accuracy and Reproducibility

In order to test the accuracy and reproducibility of the respirometers a mercury burette was attached to the large respirometer at V (Fig. 1) or to the small respirometer at G (Fig. 3). Known volumes of mercury simulating typical oxygen uptakes by insects were then run from the burette when the electrolytic units were in operation. The net volumes of oxygen at S.T.P. required to restore the electrolyte levels and the recorded volumes of oxygen actually generated electrolytically were calculated. A series of 2·5 ml. volumes were measured, this volume representing the oxygen uptake of about 25 adult houseflies in the large respirometer in one hour. The mean volume of oxygen generated was 99·1 per cent of that simulated by the mercury burette with a coefficient of variation of ± 5·2 per cent. In a similar series representing the oxygen uptake by a single housefly placed in the small respirometer during a 20 hr. period the mean volume generated was 97·8 per cent of that simulated with a coefficient of variation of ± 2·2 per cent. It is believed that a considerable improvement in reproducibility could be achieved, if desired, by better temperature control of the apparatus and cabinets.

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An O-Ring Modification for Vacuum Desiccators

by R. B. Beevers, B.Sc., Ph.D.

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DURING the winter months or after a period of evacuation, vacuum desiccator lids can be extremely difficult to remove. This is particularly the case with desiccators of large diameter. Removing the lid can be very time-consuming and, occasionally, result in the enclosed material being upset. A simple device to avoid this difficulty and which has been used satisfactorily for several years is shown in Fig. 1. It consists of a rubber O-ring (R) of diameter suitably chosen to fit the ground flanges (F) and a turned metal ring (M) which serves to keep the O-ring in a circular shape, thus guarding against an implosion during evacuation. A wide range of O-ring sizes are available to suit any desiccator. In cases where organic vapours are likely to have a deleterious effect, rings of different types of rubber can also be obtained.

In the arrangement used in this laboratory O-rings of 9·00 in. internal diameter, cross section of diameter 0·250 in. made from a general purpose synthetic rubber of 80° hardness (British Standard degrees) were used to seal vacuum desiccators of $8\frac{5}{8}$ in. internal diameter with a $\frac{3}{4}$ in. wide ground zone on the flange (F). The ring M was turned from $\frac{1}{8}$ in. aluminium sheet to have an outside diameter of 9·00 in., the width being approximately $\frac{3}{4}$ in. The metal ring was found to give adequate support to the rubber ring.

The device is particularly suitable in the laboratory when repeated evacuations are to be carried out, for example when drying delicate glassware to constant weight. With care in the cleaning of the ground surfaces and the surface of the rubber ring a vacuum desiccator fitted with an O-ring, as described, was found to hold a vacuum of 10 mm. Hg. for at least 12 days so that limited periods of storage are possible. A thin film of silicone high vacuum grease applied to the surface of the O-ring assists in sealing particularly where the ground surfaces are rather coarse.

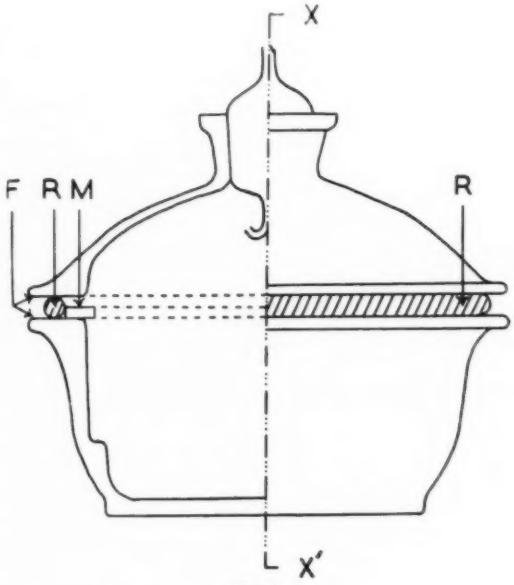


Fig. 1

THE WARREN SPRING LABORATORY

IN setting up Warren Spring Laboratory 'to carry out process research and development over a wide field not limited to particular areas of technology', the Research Council for the Department of Scientific and Industrial Research expressed their conviction that, when necessary, the Department's Research Stations should change in function and objective to meet the needs of changing situations. The Council considered that the Fuel Research Station had largely fulfilled the aims in view when it was set up, and that current needs were satisfactorily catered for by researches going on elsewhere; they decided, therefore, to close down the Fuel Research Station, and to transfer the staff to a new Laboratory in Stevenage, with new programmes. To ensure that there should be no likelihood of an impression being gained that the Fuel Research Station was being continued at Stevenage, or that the title of the Laboratory might appear to restrict the field of activity, the new Station is named after a lane which used to run across the site.

Of the work carried out at the Fuel Research Station only two programmes have been transferred to the new Station, namely, research on the abatement of atmospheric pollution, and on the synthesis of oils and chemicals by the Fischer-Tropsch process.

There had been a number of substantial indications of need for research in the field of mineral processing, and it was decided that this should form one of the new projects to be undertaken; there had also been indications of need for work on a pilot scale in various fields which the Department had not been able to meet. With these pointers, it was decided to build a laboratory in a modern industrial style, to be as flexible as possible, to house in the first place a staff about the size of that of the Fuel Research Station, and with facilities for both laboratory research and pilot-scale work.

Buildings

The main three-storey laboratory building is 372 ft. long and 37 ft. 6 in. wide. It is based on a four-foot module, the module being expressed elevationally by vertical posts supporting floors and roof, and by internal posts centrally along the length. The main spine corridor is set to one side of the central supports. The only solid internal walls are those of the corridor and the secondary staircases; all other partitioning is of light, demountable, prefabricated construction, which can be placed in any desired position between the outer walls and the inner corridor walls, subject only to the basic four-foot module.

Gas, water, electricity, compressed air, are available at every third module (12 ft.) along a perimeter distribution system. Benches are normally arranged in peninsular fashion, i.e. at right angles to the windows.

The building is heated by panel-type radiators; make-up, dummy panels matching them are inserted between the radiators to give the appearance of a continuous radiator panel along each wall between the concrete columns at 12 ft. centres. The radiators and the dummy panels conceal the services which run around the perimeter of the building. The dummy panels can be readily removed when service connections are required.

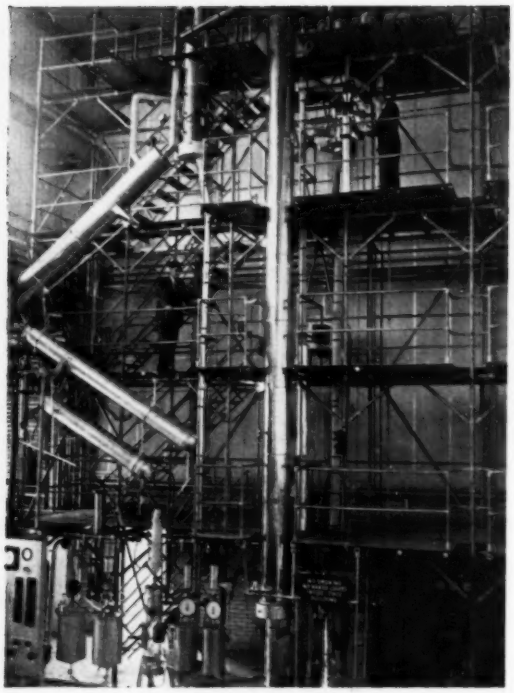
Fume cupboards are ranged along the inner corridor walls, each cupboard having its own extract duct which discharges at roof level.

The finishes are simple, self-coloured fair-faced brickwork being used throughout, except in laboratories with special functions. With the exception of laboratories which are adapted for wet processes, floor finishes are in linoleum.

A three-storey administration block runs at right angles to the main laboratory building; it is similar in construction and design except that there is a lower ceiling height.

There are three pilot-scale buildings, each 90 ft. long by 55 ft. wide by 37 ft. 6 in. maximum height. In two of them, a 20 ft. wide section is 20 ft. high only. These buildings are linked to the main laboratory block by a corridor with small scale laboratory units on each side. The buildings have folding doors to the side bays to permit the introduction of heavy plant at any point. The structure is carried by pre-cast concrete posts. Vertical cladding, above a brick protective walling, consists of asbestos-cement sheeting and patent

Work on gas analysis.



Synthesis of oil from coal by the Fischer Tropsch process.

glazing; the roofs are of asbestos-cement decking overlaid with bituminous felt.

The workshops and engineering stores occupy a large steel-framed building comprising six east-light bays, each 60 ft. by 30 ft. minimum headroom.

Since steam is required night and day for process purposes, two fully-automatic, oil-fired high-efficiency boilers are used, with a nominal pressure of 120 p.s.i.; one is rated at 10,000 lb. and one at 5,000 lb. of steam per hour. The front of the boiler house is fully glazed with a patent system permitting ready removal in sections when boiler tube replacements are necessary, so that it was possible to reduce the dimensions from front to rear. A high-level water reservoir, in reinforced concrete, has been designed integrally with the boiler flue, and forms a local landmark.

Service mains run in open, splay-sided trenches to avoid the expense of underground ducts or the unsightliness of overhead gantries.

The total cost of the establishment, including buildings, services fixed, laboratory fittings, library bookshelves, and all site works is approximately £620,000., i.e. a rate per sq. ft. of £6. 7s. 0d.

Programmes

Atmospheric Pollution.—Purely by coincidence the closing of the Fuel Research Station occurred simultaneously with the introduction of the Clean Air Act; it was therefore particularly apposite to review the programme in starting at the new station. The work now being undertaken follows naturally from that begun at the Fuel Research Station, and is designed to meet the requirements of the Ministry of Housing and Local Government.

The principles of smoke elimination that have proved successful in reducing smoke from hand-fired boilers on land are being applied to marine boilers.

The possibility of developing after-burners to burn smoke in various situations is being investigated.

The properties of smokes from different sources are being examined with special reference to the constituents that might be injurious to health. The occurrence of oxides of nitrogen in the atmosphere under different conditions is being studied.

In the new investigations of air pollution there is a need for greater accuracy than has been possible in some of the measurements made in the past. As a matter or urgency a review is being made of the principal instruments at present in use; this work is being undertaken by the Scottish Branch of the Laboratory at Thorntonhall.

Micro-surveys are in progress to examine the concentration of various types of pollution at different types of site in a limited area. The results of such investigations will be important, for instance, in helping to determine the value of smoke-control areas, and in assisting those responsible for deciding the height and siting of large industrial chimneys.

Much of our present knowledge of atmospheric pollution depends on the co-operative observations which have been made for many years by local authorities and other organizations in collaboration with the Fuel Research Station. The scheme is being revised to meet the circumstances which follow the Clean Air Act.

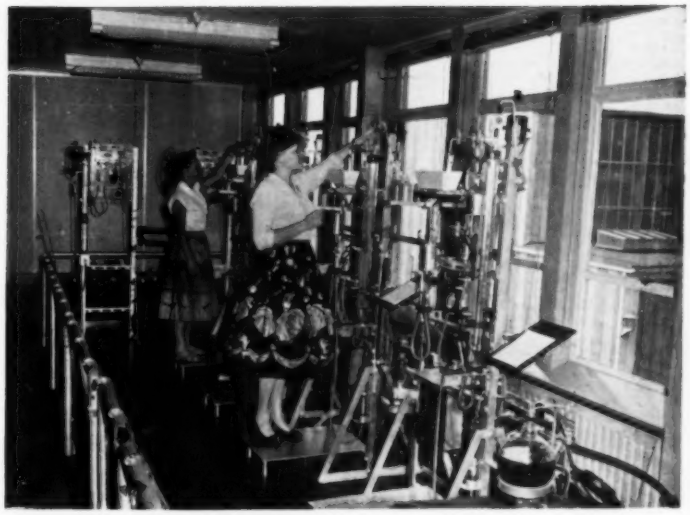
Process Development.—A decision to continue the studies of the synthesis of oils and chemicals from carbon monoxide and hydrogen was taken at the request of the Ministry of Power as part of a project to develop, if possible, an economic process for producing oil from coal. The work is also important, however, as an investigation involving development between the discovery of a reaction of potential industrial importance and the design and building of full-scale commercial plant.

The development of oils from coal is a two-stage process: the first stage involves the complete gasification of the coal to yield a mixture of carbon monoxide and hydrogen, and the second the catalytic conversion of the gas mixture into the desired end-products. The work at Warren Spring Laboratory is concerned only with the second of these stages. Economic considerations indicate that the most promising version of the Fischer-Tropsch process for use under British conditions is that known as the slurry process, in which the gas mixture is passed through a suspension of powdered catalyst in molten wax at temperatures in the range 250 to 300° C. and at pressures between 5 and 30 atmospheres.

The objectives of the programme are:

(i) to develop an iron catalyst of longer life and higher activity than those at present available and one that will yield a high proportion of desired end-products;
(ii) to select operating conditions (gas composition, temperature, pressure) to combine a high reaction-velocity with a given distribution of end-products;
(iii) to obtain data necessary to design a full-scale reaction vessel.

Mineral Processing Research and Development.—The proposal to undertake research on mineral processing followed a suggestion in the Ninth Report of the Advisory Council on Scientific Policy (1955-56), and consideration by the Research Council of opinions expressed at a conference



A further view of the department for work on gas analysis.

on industrial productivity arranged by the Department in 1954, and at a subsequent symposium arranged by the Institution of Mining and Metallurgy in 1955, and after consulting many experts in the field. There was considerable variation in opinion as to the extent and nature of the need for such work, but there was a positive indication of the need for a centre for advanced research in mineral processing in this country.

Dr. M. G. Fleming of the Bessemer laboratory of the Royal School of Mines has been appointed Consultant to the Division.

It seems probable that for some time a fair proportion of the effort of the Mineral Processing Division will be engaged on sponsored work on particular ores, but it is hoped that basic investigations will include:

(i) a study of grinding in the presence of additives such as surface-active agents;
(ii) the kinetics of bubble attachments to mineral surfaces, as a contribution to the knowledge in the field of froth flotation;
(iii) a study of the behaviour of mineral particles in a high tension field, and the modification of this behaviour by various surface treatments.

The laboratories are equipped to handle most laboratory-scale mineral-dressing operations such as flotation, jigging, tabling, heavy-media separation, wet and dry magnetic separation, and high voltage separation. In the hydro-metallurgical field facilities are available for atmospheric and pressure leaching for fluidized-bed roasting, chlorine metallurgy, and solvent extraction. Pilot plant facilities enable primary crushing operations to be carried out on a scale up to 2½ tons per hour, and flotation plant is available for treating up to 1,000 lb. per hour. It is possible to carry out full scale tests with radioactive tracers. The Division has a Mineralogical Section, but relies on the Physical and Chemical Services Division for its analytical work.

Chemical Engineering.—It will be apparent that chemical engineering must play a large part in practically all the major activities of the laboratory, and the decision of the Research Council to transfer 'the work on Chemical Engineering . . . carried out at the National Chemical Laboratory to Warren Spring Laboratory' will readily be understood.

The Division has three functions:

(i) to carry out research on physical operations which play an important part both in processes which are under development in the laboratory, and those in more general use in industry;
(ii) to undertake research in the field of chemical engineering sponsored by industry or by Government departments;
(iii) as a result of these functions to accumulate basic information in chemical engineering for use by other sections of the laboratory and industry.

Physical and Chemical Services Division.—This Division provides a comprehensive central service in the fields of analysis, both by chemical and physical methods, instrument development, physical measurement, and photography. Special equipment includes gas chromatography, quartz and infra-red spectrometers, and equipment for x-ray defraction and fluorescence spectrometry.

Engineering Services.—The Engineering Services Division has a drawing office which undertakes design and detail of plants for laboratory at pilot scale projects; it has an industrial staff of approximately 120, and well-equipped workshops.

Intelligence.—In addition to the library and editorial services which are essential to any Research establishment, the Intelligence Division is setting out to provide an information and project appraisal service. A start has been made, for instance, in building up a centre of information in Mineral Processing, by assembling data from a wide variety of sources in such a way that they can be used in many ways. Information of this kind will be most useful in deciding the worthwhileness of practical investigations before they are started.

Balance of Programme

From what has been described it will be apparent that there is a wide choice of field before Warren Spring Laboratory, and that at the moment the main problem is that of selection, and of allocation of priorities. In addition to the factors which govern the work of other D.S.I.R. laboratories, there

(*Concluded on page* 387)

IMPROVEMENTS IN LABORATORY TECHNIQUES

by J. Glover

Chief Milk Chemist, Co-operative Wholesale Society Ltd.

THE general attitude of our industry to science in the early days was so unenlightened that there were few laboratories in existence and these were primitive in design and limited in scope to butterfat and total solids estimations.

After World War I the alteration in the organization of the industry, the introduction of the manufacture of products other than butter and cheese, combined with the effect of legislation and a greater appreciation of the value of scientific control, led gradually to the modern and, for their purpose, well-equipped laboratories of today.

The formation of bigger units within the industry has undoubtedly stimulated a greater interest in the value of laboratory control, which has been further strengthened by the introduction of graded and designated milks, necessitating greater dependence on laboratory control to assure conformity with the Regulations.

Larger dairy firms have set up central laboratories where the expensive apparatus of specialized research and specialized staff can be concentrated so that the development work can proceed side by side with the routine control work of the dairy laboratories.

The routine control laboratory is equipped and staffed to deal primarily with the quality of the milk received, the product despatched, to make sure that all legal requirements are satisfied, and to provide guidance on maintaining and improving the efficiency of the conditions of processing. Additionally, it may be required to control water treatment plant, boiler feed water treatments, refrigeration brines and effluent disposal systems.

All laboratory work is costly in materials and apparatus, and our scientific workers, while always seeking greater accuracy or more revealing tests, have made efforts to overcome this by simplifications and time-saving methods wherever possible.

Considerable contributions to dairy control work have been made by laboratory furnishers, by way of the production of apparatus of a high degree of accuracy, and their willingness to incorporate into the design of standard equipment such automatic control and labour saving features, has considerably enhanced the efficiency of such units.

The Creamometer and Lactometer were probably the earliest of tests used for milk. The former indicated the measurement of the cream forming on a sample standing in a graduated tube, whilst the latter was merely a hydrometer with a scale adapted to milk in which the percentage of total solids was read off directly. By the turn of the century the Gerber method for butterfat estimation in milk had come into general use, and with small refinements this method has remained the universal control method to the present day in this country.

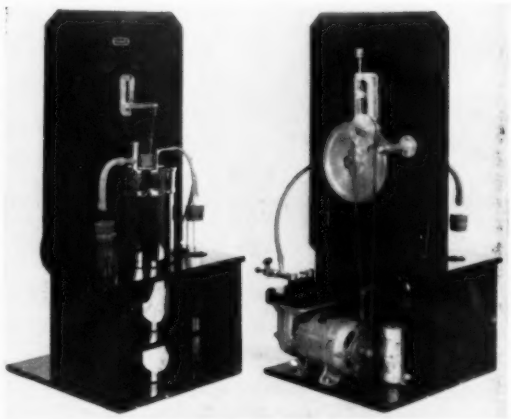
In 1936 the British Standards Institution produced a Standard Method No. 696[1] in two parts, setting out in considerable detail the methods to be used, the quality of the reagents, and the specifications for glassware and centrifugal machines. Prior to World War II, the glassware and the centrifuge machines used in the test were of continental manufacture, and consequently from 1939 became unobtainable from this source. Manufacture commenced in this country at a time when materials and manpower were at a premium and it is not surprising that some of the wartime equipment supplied to laboratories failed to reach the recommended standards set out in B.S.696, 1955[2]. Happily, this position has considerably improved and at least two laboratory furnishing firms have produced greatly improved designs of the centrifuge machine which conform to the British Standards recommendations, e.g. the Astell-Cowan machine incorporates such admirable features as a fluid drive, to give a smooth and speedy acceleration to 1,100 r.p.m., which can be maintained independently of motor speed, vibrationless spring loaded suspension, convenient vertical loading head, and acid resisting light alloy cups.

The Fucoma machine also incorporates many improvements in design.

Butyrometers of British manufacture were also subject to wartime manufacturing problems, but here again a greatly improved general standard of accuracy has now been achieved. The revised B.S.696, 1955, Part I, contained details of the automatic mercury pipette and its use for calibrating the scales of Gerber butyrometers thus enabling laboratory staffs themselves to check the accuracy of the graduated scale. The main change in the revised B.S.696, 1955, Part I, concerns the capacity of the milk pipette, which it is now specified shall deliver 10.94 ml. of water instead of 11.04 ml. as formerly. The only change in procedure in Part II is that a temperature of 65° C. is now specified for temperature adjustment of the butyrometers instead of 68° C.

Improved technique in manufacture, for which the British glassblower can be complimented, combined with improved design, have made hydrometers for density, accurate instruments for milk testing.

The original B.S.734[3], 1937, was revised in 1955[4], from which it differs only in minor respects. However, in 1957[5] an amendment was added incorporating a change in formula for the calculation of the non-fatty solids content of milk. This change resulted from information which was available



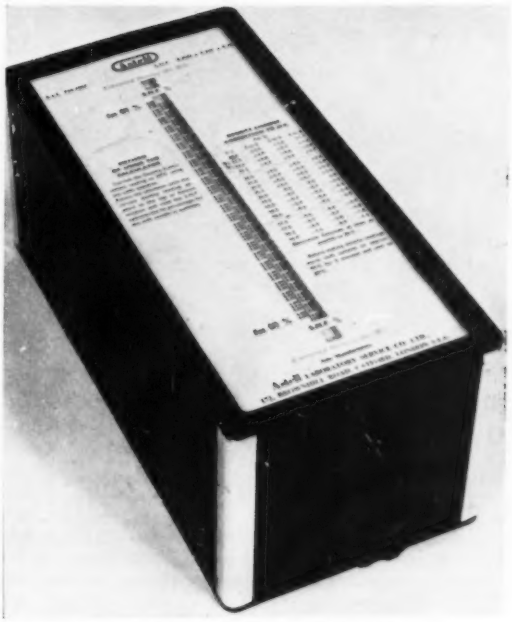
The Hortvet cryoscope (*Astell Laboratory Service Co., Ltd.*)

on the relationship between total solids determined gravimetrically and by hydrometer. This indicated that the calculated total solids was lower than that obtained by drying. In addition the formula required alteration to take into account the change in size of the milk pipette from 11·04 ml. to 10·94 ml. The new formula now reads TS = 0·25D + 1·22F + 0·72. This has the effect of raising the non-fatty solids by approximately 0·1 per cent above that obtained from the old formula. 0·04 per cent being due to the change in size of the milk pipette and 0·06 per cent to the difference between dried and hydrometer estimated total solids. In addition, an alternative method and formula were specified for determining total solids by hydrometer with the fat in the solid condition, i.e. after storage of the milk sample overnight in a refrigerator at 45° F. or lower. The formula for this method is TS = 0·25D + 1·22F + 0·55. In this connection manufacturers of laboratory equipment have shown considerable enterprise by the production of equipment of an automatic nature primarily in the interests of speed and accuracy of testing.

Automatic lactometer jars, thermostatically controlled water baths for heating to 40° C. and cooling to 20° C. and a very pleasing and extremely convenient rapid solids-not-fat calculator designed to replace the unwieldy British Standards Tables, which gives accurate direct readings for S.N.F. based on the amended B.S. formula for fat in the liquid phase are other examples.

The national schemes now in operation to improve the compositional quality of milk from the farm have served to emphasize the absolute necessity for standardized methods of testing. Only by such means can reproducibility and accuracy of testing be achieved and any indication of national trends be reliable and informative.

The decline in milk compositional standards especially non-fatty-solids during the past 20 or 30 years gives rise to considerable embarrassment at the creameries in the late winter and early spring seasons, when the composition of bulk milk usually falls below the presumptive legal minimum standard. As a result of these conditions the use of the Hortvet freezing point apparatus has become an essential in every creamery or dairy laboratory. The British Standards Institution has just produced a very welcome B.S.3095, 1959[6], giving precise details of method and apparatus to be used.



The Astell rapid solids-not-fat calculator.

The B.S., however, details the apparatus in its basic form, which involves many time consuming inconveniences and possible hazards in the use of ether as coolant.

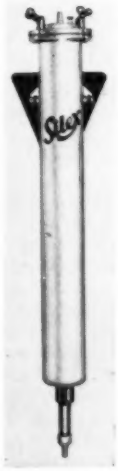
An automatic Hortvet cryoscope, conforming to B.S.3095, recently put on the market, is fully mechanized, with an electrically driven stirrer and air compressor, and a safety ether replenishment device designed to obviate the necessity of exposure of ether to the atmosphere when 'topping up' with this highly inflammable material.

Much work has been undertaken to devise simpler and more rapid methods for the determination of the total solids in milk. Tramer and McWalter[7] report upon methods, using a moisture balance procedure, a direct titration method and a testing method using an infra-red drying lamp. It would appear, however, that such methods do not as yet fulfil all the requirements of accuracy and speed required for routine testing of large numbers of producers' samples.

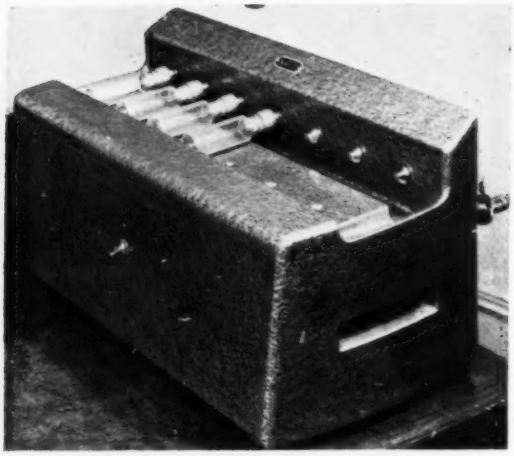
The Technico test unit for the estimation of fat, total solids and moisture, more generally used in the manufacturing creamery laboratory, has recently been completely redesigned, to overcome hazards occasioned by the concentration of ether fumes, and in conjunction with the C.W.S. Milk Department, a new system of feed of reagents to the automatic burettes has been devised by the use of a vacuum manifold linked to a water pump.

Davis has shown that the titratable acidity of milk can differ by as much as 0·02 per cent 'lactic acid' according to the amount of indicator used. The method has now been standardized in all its aspects, especially in the amount of indicator used. The amount specified is 1 ml. of 0·5 per cent phenolphthalein in 50 per cent alcohol, per 10 ml. of milk titrated.

The British Standards Institution have recently published Specifications[8] for the analysis of milk and milk products



Silex Minor portable deionizer (*Ionex Water Treatment Equipment Co., Ltd.*).



Roll tube equipment (*Astell Laboratory Service Co., Ltd.*)

generally. These have been of tremendous help to laboratories by bringing about a standardization of techniques, and in consequence more reliability of results between laboratories.

Thus the chemical tests employed in our laboratories now have prescribed techniques with definite standards which are generally adhered to by the different authorities and by the industry.

The same, however, is not true of the bacteriological tests employed. In this sphere a multiplicity of tests is used; in addition the techniques employed—apart from those used for statutory requirements—are sometimes varied to suit local conditions and, worse still, the interpretation of results may be subject to wide variation by different laboratories.

However, improvements in bacteriological testing have been brought about in

(*a*) tests for marketability of raw milk;

(*b*) tests for grading, advisory and statutory purposes;

(*c*) tests for specific bacteriological abnormalities.

In 1943 the National Milk Testing and Advisory Service introduced the ten minute rapid Resazurin platform test[9], owing to the unreliability of any instantaneous marketability test. While it has been criticized, the fact remains that it is the best and speediest reliable test we have at present for raw milk marketability. It is now widely used for rejection purposes and it is the platform rejection test recommended by the Joint Milk Quality Control Committee in its scheme to improve the hygienic quality of ex-farm milk supplies. The standard disc number for rejection being 3½ and under.

The 1949 Milk (Special Designations) (Raw Milk) Order[10] adopted the standard methylene blue test for tuberculin tested raw milk as a grading test at the point of production. The majority of milk produced in this country is now tuberculin tested, and is sold by retail as pasteurized (T.T.) milk, and is subject to the statutory tests for such milk.

The introduction of legislation concerning graded milks, viz., the Milk (Special Designations) Regulations, especially pasteurized and sterilized, of necessity developed concurrently the employment of a more intelligent and better qualified worker capable of carrying out both the chemical and bacteriological tests required. Indeed the work carried out in the larger laboratories threw considerable light on the bacteriology of milk, both raw and pasteurized, as well as considerable doubt upon the value of the tests prescribed.

Thus in 1946 the unsatisfactory plate count, the official test at that time was replaced by the Kay and Graham phosphatase test[11] for pasteurization efficiency. Although the test was published in 1935 it was not until 1946 that this classical and delicate phosphatase test for measuring the efficiency of pasteurization became the official test in place of the plate count.

Although the Kay and Graham test is still the official test laid down, increased use is now made of the quicker Aschaffenburg and Mullen test[12] as modified by Tramer and Wight[13] for routine control work in pasteurizing dairies, especially since Aschaffenburg introduced the use of the sodium carbonate/bicarbonate buffer in place of the sodium veronal buffer[14], thereby simplifying testing and at the same time reducing the cost of testing.

The same Regulations made the methylene blue test a statutory test in place of the coliform test.

Another important contribution to dairy science was made by Aschaffenburg by providing the turbidity test[15] which is now the statutory test for sterilized milk.

Fellows [16] has reported on a new test for sterilized milk based on the reducing capacity of potassium ferricyanide. This test will not merely determine whether the minimum statutory heat requirements have been satisfied but will also indicate the degree of heating which has taken place in the normal sterilizing process.

Burton [17,18] has made a study of the effect of heat treatment on the colour of milk and describes an apparatus for measuring it.

In the quality control of pasteurized milks, the methylene blue test after storage is used to detect post pasteurization contamination, the extent of which determines the K.Q. of the final product. Swab and rinse tests of milk utensils and plant surfaces are generally assessed by employing the plate count and coliform test. Standard techniques are prescribed for these tests and with properly cleansed utensils and plant, the colony count should not exceed 5,000 per sq. ft., while for churns and milk bottles the counts should not exceed 50,000 and 200 per vessel respectively.

There have been some considerable advances in the method of carrying out bacterial counts on milk and milk products.

The advantages of the roll-tube method over the conventional plate method for the determination of colony counts had long been recognized for routine control purposes, on the grounds of greater convenience, and enormous economies in glassware and labour costs.

The absence of suitable equipment for routine purposes probably limited the comparative work necessary to assess its relationship with the traditional Petri-dish technique.

The production of a streamlined roll-tube apparatus in 1949, by Astell, in which the whole process was fully mechanized, led to a considerable number of successful investigations into the reliability of this method. It has become firmly established as an accepted technique for routine colony counts by creamery laboratories because of the economy in media, equipment and labour which it affords.

Making media in the laboratory is a laborious process and the introduction of dehydrated media by Oxo has proved to be a great time saver especially when used in conjunction with the roll-tube apparatus.

Many investigations have been undertaken concerning specific abnormalities in milk, of the more important, the fault of 'bitty' cream in pasteurized milk seems to be becoming more prevalent. This condition is caused by strains

of *B. Cereus* and *B. Mycoides*, which produce spores which are not destroyed by pasteurization.

Stone and Rowlands[19] have shown that although simple tests can be employed to demonstrate the presence of the causal organism and the rapidity with which bittiness will develop in a milk supply, it is impossible to eradicate the cause since the organisms are likely to be present in the majority of raw milk supplies to some extent and the only measure of control appears to be in the cold storage of milk at 40° F. or lower until delivery to the consumer.

A great deal of work has been done and splendid remedial measures put forward to eliminate phage infection of lactic starter cultures, which has for long been one of the major problems in the commercial manufacture of cheese. Normal methods of propagation in the laboratory do not provide adequate safeguards against airborne phage infection. Methods hitherto available have proved quite inadequate to prevent infection with phage from the surrounding air.

Lewis describes a new method[20] of handling both laboratory and bulk starters which removes all possibility of infection with airborne phage particles.

Laboratory cultures are propagated in polythene bottles fitted with a patent airtight rubber seal. Bulk starter cans are fitted with airtight lids with a central hole to take the seal. Transfer of inoculum from one bottle to another or from the bottles to the bulk starter cans is made through specially constructed surgical type needle units, the collapsible polythene bottles being squeezed to discharge the inoculum. Thus at all stages of manufacture absolute asepsis is assured.

A novel and effective improvement in the art of cheese starter preparation has recently been patented in this country. A decalcified milk preparation known as phage resistant medium[21] is used to prepare the working starters. It is claimed that bacteriophage cannot attack starter organisms grown in P.R.M. and so cannot multiply, and that cultures based on P.R.M. develop normally in spite of heavy concentration and phage, if present, dies out during incubation.

The use of antibiotics in veterinary science and nutrition has had important repercussions in dairying. Minute traces of antibiotics have an inhibitory effect on the micro organisms required for starter preparation and cheesemaking. Because of the nature and low concentration of these compounds their presence in milk is difficult to detect before the milk is used in the dairy.

A comparatively simple biological test[22] which can be made in 2½ hours will readily detect antibiotics. Distinct advantages of this test using triphenyltetrazolium chloride are:

1. The same equipment used for the methylene blue test can be used;
2. The test is sensitive to all the antibiotics that are commonly used to treat mastitis;
3. The test will detect inhibitory substances other than antibiotics which may cause difficulty in the manufacture of dairy products;
4. The test can be performed by a person familiar with simple laboratory technique.
5. The cost of materials for the test is very small.

Chemical tests for milk products are conveniently dealt with by the British Standards Institution under the respectively named products, while the bacteriological examination of such products appears to be one in which individual firms determine the type of examinations best suited to them which are indicative of high quality and a long shelf life.

Separator efficiency checks can now be carried out speedily by the plant operator, using an apparatus known as the Sepascope, thus avoiding the necessity for frequent Gerber tests in the laboratory. The Desco Sepascope claims to check separator efficiency to 0·06 per cent in two minutes.

Attempts have been made recently to control the strength of detergent by instruments, and various types have been suggested. These instruments are usually based upon the conductivity of the solution and a simple instrument such as the detergent concentration indicator appears to be suitable for this purpose.

The conventional glass still used for the preparation of high quality distilled water in the laboratory is gradually being replaced by water deionization processes. Several firms have recently developed equipment for demineralizing water by ion-exchange treatment and laboratory sized units are available from several sources. These units need neither heat nor power and produce demineralized water at a fraction of the cost of distillation. The Ionex water deionizer is a particularly convenient model inasmuch as exhaustion of the mixed resins is colorimetrically indicated by means of an indicator fitted to the outlet.

It is apparent that in recent years a practical outlook in laboratory control of processing has been developed. Statutory tests have become simpler and speedier, apparatus has been mechanized to a high degree by the incorporation of automatic and labour saving features, whilst better trained laboratory staffs able to test and interpret the results obtained have revealed to those directing this important industry the advantages of what science can offer in the future.

Reprinted from *Dairy Industries*, **24**, 601.

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Recent British Standards

Testing Cellulose Acetate Flake

Three test methods which had not been completed when B.S. 2880: 1957 was published are given in this new publication, Addendum No. 1 to B.S. 2880 (price 4s.).

The methods, which are described in conjunction with three full-page diagrams, are:

1. Determination of insoluble particles.
2. Determination of original colour, and colour after the heating of plasticized cellulose acetate.
3. Determination of viscosity loss on moulding.

The 11-page specification provides full details of apparatus, procedure and methods of expressing results.

Copies of this Standard may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1.

GRAPHICAL DIAGNOSIS OF INTERLABORATORY TESTS

The National Bureau of Standards has worked out an interlaboratory test scheme that employs a minimum of mathematical statistics while yielding, in most cases, results that are especially easy to interpret. The method is expected to be particularly useful for co-ordinating quality control tests on the same product carried out by laboratories in different plants of the same company.

A SIMPLE way to analyse the discrepancies between different testing laboratories that presumably use the same test procedure was recently worked out at the National Bureau of Standards.* Devised by W. J. Youden of the NBS applied mathematics laboratory, the method employs a graphical presentation of the test data which allows each laboratory to tell at a glance how its performance compares with that of others. The graph can point the way to corrective action to eliminate the bias, if any, in the technique used by a particular laboratory; or it may indicate the need for an improved test procedure—one that lends itself better to uniform application by all laboratories. In addition, it provides an estimate of the precision of the test-procedure results.

Discrepancies, Normal and Abnormal

Duplication of tests by two or more laboratories is constantly being undertaken in science and industry in order to verify results, to detect systematic errors, and in general to monitor the techniques of measurement. Sooner or later all important results in the physical sciences are checked by other laboratories. In industry, the same quality control tests may be used by the various plants of a single company and—perhaps alternatively—the same acceptance tests are performed by laboratories at different depots of the purchaser.

In all such cases, discrepancies in the results from different laboratories are not only expected, but inevitable. It is basic to all measurement processes (except those of the crudest sort or those involving only simple counting) that when the same procedure is repeatedly carried out on the same specimen with the same equipment and personnel, the results are not all identical but are scattered over a certain range of values. When the same measurements are made by a number of different laboratories, using nominally identical equipment, the scatter is even greater. In any case, the more precise the procedure, the narrower the range of scatter.

However, when the scatter is unusually large or when a particular laboratory differs markedly from most of the others, something must be wrong. The problem—which the present method of analysis is intended to help solve—is to determine just where the difficulty lies. The difficulty may be due to a number of factors, some of the most important being (1) intrinsic lack of precision in the procedure; (2) faulty technique in carrying out the procedure; (3) ambiguity or vagueness in the formulation of the procedure, causing differences in the way it is applied by different laboratories; (4) differences in the specimens measured; and (5) simple mistakes, such as misreading a dial.

Co-ordinating Industrial Tests

The importance of identifying the factors responsible for the discrepancies is clear enough in scientific research. In industry, undiagnosed errors in the carrying out of quality control tests and errors intrinsic to the test procedure itself are a severe handicap to efficient production. To allow for testing errors, the usual practice is to aim at a higher quality product than the specifications call for. The larger the test errors, the greater the amount of excess quality needed to ensure that a reasonable proportion of the finished items will pass the tests—which are still based on the same specifications. Even a modest improvement in the precision or in the uniformity with which tests are carried out could thus lead to a substantial drop in costs.

Under the stimulus of a high rate of new-product development, much attention has recently been given to the problem of co-ordinating quality control or acceptance tests in different laboratories. These schemes often use advanced statistical techniques to attack the problem with various degrees of thoroughness, but the practical results have been generally disappointing.

Part of the difficulty seems due to the very sophistication of the methods used. Though modern mathematical tech-

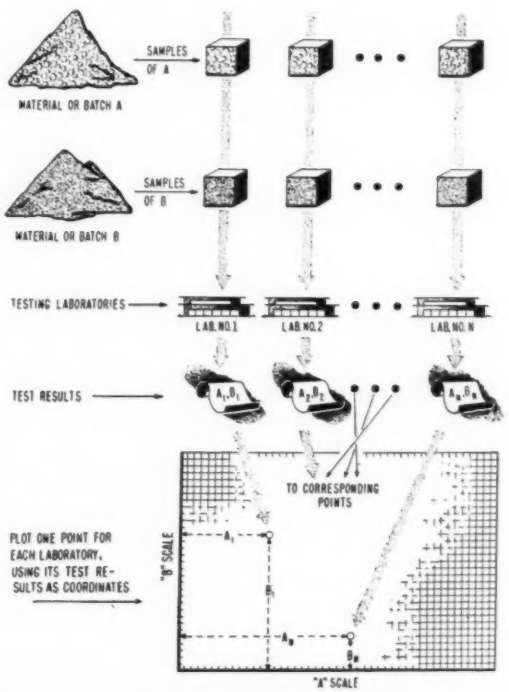

Fig. 1. Statistical design for diagnosing discrepancies in results from different testing laboratories.

*For further technical details see the following articles by W. J. Youden in *Ind. and Eng. Chem.*: Presentation for action, **50**, 73A (Aug. 1958); Product specifications and test procedures, **50**, 91A (Oct. 1958); Circumstances alter cases, **50**, 77A (Dec. 1958); What is a measurement? **51**, (Feb. 1959, in press).

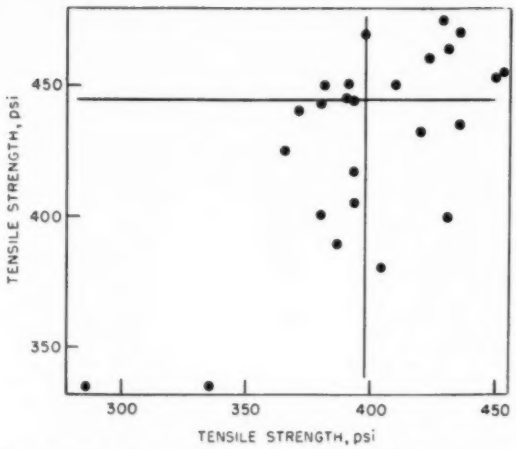

Fig. 2. Plot of seven-day tensile strength of two cement samples as reported by 25 laboratories.

niques have added many powerful tools to the statistical analyst's arsenal, their use demands considerable skill. In contrast, experience with the present method indicates that in a large majority of cases it provides data that 'speak for themselves'. However, there are circumstances that require a more elaborate or comprehensive inter-laboratory test design; but even in such cases the present method might well be used for a preliminary survey of the situation.

The Statistical Design

In the present statistical design, samples of two fairly similar materials, A and B, are sent to the various laboratories; and each laboratory is asked to carry out the test procedure on each sample. The test results may be single readings or averages, provided that the same number of readings are used for each average. (If there are only a few laboratories, a second pair of samples is distributed later; this is of advantage even when not required by the fewness of the laboratories.)

When the results come in they are used to prepare a graph. The two test measurements from each laboratory are interpreted as the co-ordinates of a single point; the x co-ordinate is the test result on sample A and they co-ordinate the result on sample B. There is thus one point for each laboratory (Fig. 1).

A horizontal median line is then drawn, i.e. a line parallel to the x-axis and placed so that there are as many points above the line as there are below it. A second median line is drawn vertically, i.e. parallel to the y-axis and so that there are as many points to its left as to its right.

For example, when two cement samples were sent to 25 laboratories for tests of seven-day tensile strengths, the results gave the graph shown in Fig. 2. Here two of the laboratories were so definitely separated from the other 23 that they were not used in locating the median lines.

Interpretation of Graph

The most important general feature of the graph is the way the points are distributed among the four quadrants into which the graph paper is divided by the median lines. If only random errors of precision were present the points should be equally numerous in all quadrants.

However, in all cases to which the method has been applied thus far, there has been a more or less definite tendency for the points to concentrate in the upper right and lower left quadrants. In view of the way the points were obtained, this means that some laboratories tend to get high results on both samples and other laboratories get low results on both samples. That is, it indicates the presence of individual laboratory biases. Evidence of this state of affairs is seen, for example, in the cement tests (Fig. 2).

The more pronounced the individual laboratory biases, the greater the departure from uniform, circular distribution of the points about the intersection of the medians. Fig. 3 illustrates a case in which the points (with a few exceptions) lie in a long narrow oval with its long axis at about 45° with the x-axis. These points were plotted from phthalic anhydride determinations reported by 15 laboratories on two samples of paint.

Results of the kind shown in Fig. 3 suggest rather clearly that the test procedure needs more careful formulation. In its present form the procedure is apparently open to individual modifications that produce differences in the results obtained. Indeed, the more carefully each laboratory follows its own interpretation of the test procedure, the more closely the points will cluster along the 45° line.

Deviant Laboratories

Points that deviate far from the intersection of the medians tend to fall into two categories. Either they are far out but close to one of the median lines or they are far out but close to the 45° line (see Fig. 3 and 4).

In the first case, the result is fairly good on one material and rather bad on the other. A single instance of this kind might be due to a simple mistake or blunder; but if the same laboratory obtains similar results in succeeding pairs of materials, carelessness may be the reason.

A quite different explanation applies to a point far out on the 45° line. Here the laboratory in question is doing very consistent, careful work; but it has introduced some modification into the procedure so that the results are all too high (or too low). A thorough check on its procedure to discover the source of the bias is in order.

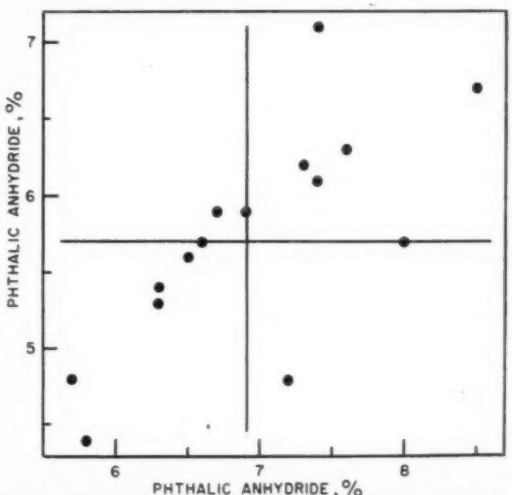

Fig. 3. Results of phthalic anhydride determinations reported by 15 laboratories in two samples of paint.

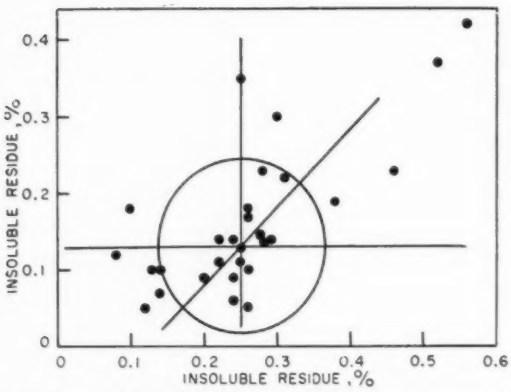

Fig. 4. Per cent insoluble residue in two samples of cement as reported by 29 laboratories. Circle has radius equal to 2·5 times the standard deviation. According to elementary statistical theory, 95 per cent or more of the points are expected to fall inside the circle if there are no systematic differences in the techniques used by the different laboratories.

In the copy or the interlaboratory test report that is sent to a particular laboratory, it might be helpful to circle its point in red. This would save the laboratory the trouble of consulting its files to locate itself and would present a vivid picture of its position in respect to the other laboratories.

When an individual point is exceptionally far from the intersection of the medians it is better not to compress the scale in order to include it in the graph. As was done in the example of the cement tests (Fig. 2), such points should be ignored in locating the median lines.

Estimating Precision

The graphical presentation of test results, as described above, may also give information on the standard deviation (σ) of a single result. An estimate of σ can be obtained rather simply if it is assumed that (1) the two materials are sufficiently alike so that the dispersion among the results for A should be about the same as that for B; and (2) the differences in precision among the various laboratories are relatively unimportant in comparison to other sources of difference. The first condition can be satisfied by proper choice of the materials and experience shows that as a rule the second condition is then also fulfilled.

One way to get the desired estimate, under the assumptions mentioned, is to find the average distance of the points from the 45° line through the intersection of the medians, and then to multiply this average by $\sqrt{\pi/2}$ or 1·2533. Alternatively, the same estimate can be found by simple numerical calculations from the given results for A and B, without having to measure distances on the graph.

According to elementary statistical theory, a circle centred on the intersection of the medians and having a radius of 2·5 σ should contain 95 per cent or more of the points provided there are no constant errors. Laboratories whose points fall outside such a circle almost certainly are erratic or are following a procedure which deviates substantially from that followed by the other laboratories.

Possibility of Sample Variation

Could a pattern of points like that of Fig. 2 be caused by differences in the samples? It is not difficult to see that the answer must be in the negative. If the stock from which the A samples were taken were inhomogeneous, and similarly for the B samples, then the pairs of samples distributed to the laboratories would be of four kinds:

high in A, high in B
high in A, low in B
low in A, high in B
low in A, low in B.

Since any one of these combinations is as likely to occur as any other, the points representing the test results should be nearly equally divided among the four quadrants. A concentration of points along the 45° line cannot be charged to variation among the samples.

However, if there is a roughly circular distribution of points, but with a disappointingly wide scatter, the diagram does not reveal whether this arises from sampling difficulties or from poor precision in testing. Further light on this problem can be obtained by a modification in the method of assigning samples. If there are 2N laboratories, N *double-size* samples of each material are prepared. By mixing or otherwise, it should be possible to divide each double-size sample into two closely matching halves. The samples are now distributed in such a way that if the two halves of a particular double sample of A go to laboratories X and Y, then these same laboratories receive the two halves of a double sample of B.

If sample variation is the trouble, the points in the new graph will tend to appear as N closely spaced pairs—like double stars in the heavens. On the other hand, if the points

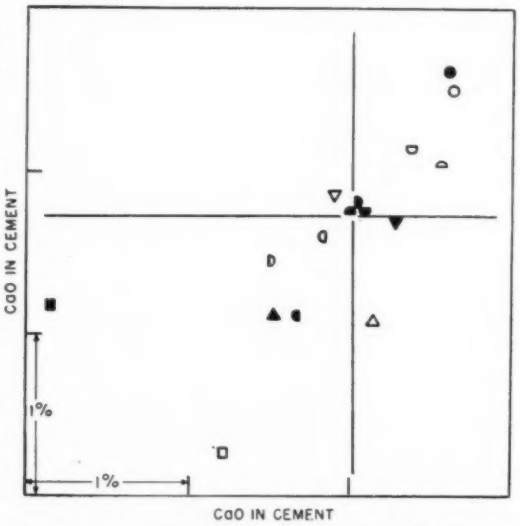

Fig. 5. Determination by eight laboratories of CaO in cement. The number of laboratories being so few, each was asked to make determinations on two pairs of samples. Hollow symbols show results for first pair and corresponding solid symbols show results of same laboratories on second pair of samples. The graph indicates that the test procedure is vulnerable to individual bias. Thus, two of the laboratories appear in the same region for both pairs. The 'circle' laboratory is very consistent and gets the highest results. The 'square' laboratory gets very low results and is not very precise as shown by the fact that its two points (hollow and solid squares) are farther apart than are the pairs for other laboratories.

corresponding to the two halves of a double-size sample are separated as much (on the average) as points from different double samples, the scatter cannot be ascribed to sample heterogeneity.

Summary of Advantages

The present interlaboratory test scheme requires of each laboratory the relatively light task of measuring only two samples; and the collation of test results involves a minimum of computation. Interpretation of the graph requires no professional statistical background to follow the reasoning; yet it permits a fairly searching examination of the test procedure itself and of the way it has been carried out by the individual laboratories.

Directions for improvement are clearly indicated. A long narrow ellipse directs attention to a more careful description of the procedure or even to the need for its modification. Points far out and near one of the medians indicate erratic work; points far out along the 45° line are strong evidence of deviations from specified procedure. Use of a circle with a radius of 2·5 σ shows the individual laboratory whether or not its technique has in some way become saddled with a substantial constant error. Experience has already shown that a certain few laboratories turn up all too frequently in the most distant positions from the intersection of the medians. Improved performance from those few laboratories may go far to restore confidence in a test procedure.

Hidden Treasure

(*Concluded from page 369*)

having himself done this. So much for the fate of a forgotten historical piece of precision optical apparatus.

The question can of course at once be raised as to whether old equipment is at all worth keeping. In certain current fields of research the answer is decisively *no*. Old electrical equipment is almost invariably virtually useless for modern research, and might as well be scrapped. The same might clearly often be the case with laboratory chemical plant. But in some other fields of research the very reverse is true. Indeed some older pieces can often be hardly improved upon, in particular those pieces that involve precision craftsmanship. If I restrict myself merely to my own very narrow field of interest mention can be made of the fact that the early glass prisms by Adam Hilger are not surpassed today. Good screws were made in past years and it is more than likely that there exist excellent measuring micrometers wrapped up in store, good lenses, gratings, crystal goniometers, optical flats, numerous polarizing devices, vacuum pumps—the list is easy to extend.

It is suggested that some attempt should be made to find out whether this conjecture about hidden hoards has a strong basis in fact or is of minor local effect only. Some important body (perhaps the Royal Society, or the British Association, or indeed a Government official) should send a suitable questionnaire to all heads of University science departments in order to seek out and prepare lists of equipment of real value but essentially redundant in the department concerned. A scheme for extended loans could well be organized for the mutual benefit of all concerned.

Clearly different disciplines might well be expected to show enormous variation in the value of such hoards, but this will emerge from the questionnaire. There is constantly the serious danger that such former equipment might either be stripped down to ruination by the young vandal (and nearly every young research worker *is* a vandal when it comes to tearing down old equipment), or equally bad, it drifts down to an elementary teaching laboratory and is quickly wrecked beyond recognition.

The matter deserves taking up, especially because of the modern decline in craftsmanship.

The Warren Spring Laboratory

(*Concluded from page 379*)

is the task of undertaking sponsored work to a greater extent, and on a larger scale. Such work may be carried out for Government departments or for industry, and it may be on a fully confidential basis. The special facilities of the laboratory will also be available for use, under certain circumstances, by teams from industry, which can work in collaboration with the research staff of the laboratory.

If the work is to become, and remain, coherent and increasingly effective as the years go by, it will be extremely important to exercise wise judgment in choice of programmes at this stage, to ensure that the programmes tend towards the deepening as well as widening of the experience of the teams engaged in research, so that they acquire outstanding knowledge and experience in fields that are of wide application.

The programme is regularly considered by a Steering Committee, appointed by the Research Council, the present members of which are:

Chairman—Sir Harry Jephcott, D.Sc., F.R.I.C., F.P.S.
Members—Sir Harry Melville, K.C.B., D.Sc., F.R.I.C., F.R.S.
Dr. R. Holroyd, M.Sc.
D. A. Oliver, Esq., C.B.E., M.Sc., F.I.M., F.Inst.P.
S. H. Clarke, C.B.E., M.Sc.

Pilot-scale Gamma Radiation Processing Plant

Research work by the United Kingdom Atomic Energy Authority on the commercial-scale use of intense radiation for industrial purposes has now reached the stage at which a pilot plant is being built for operation by the end of this year. The plant is expected to be the first of its kind and size in the world.

The new plant is being built at the Wantage Radiation Laboratories for the Technological Irradiation Group of the Isotope Research Division, Atomic Energy Research Establishment. Work on the useful employment of the large quantities of radioactive material which will become available as a result of the nuclear power programme has been in progress for some years, and this new plant will enable industrial firms already investigating the technical merit and commercial potentialities of irradiated materials to carry out full-scale trial runs of irradiation processes, such as the sterilization of medical equipment and the disinfestation of packaged products.

The cell has been designed to house half a million curies of Cobalt 60, but will be loaded initially with 150,000 curies, which will provide a through-put of 7 megarad-tons per day. As an example, in 24 hours three tons of medical products or imported animal fibres could be rendered sterile, since a sterilizing dose is of the order of 2½ rads.

Laboratory Note-Book

NEW British Standard recommendations have been published which give guidance to airlines on the handling of rhesus and other small monkeys (up to 10 lb.), intended for laboratory use.

The recommendations (B.S. 3149, part I, price 4s.)—which have been drawn up in collaboration with airline companies, the R.S.P.C.A., the Zoological Society, and many other interested organizations—specify sizes of travelling cages to ensure that each monkey has adequate space during its journey. For the airline staff who will care for the monkeys during flight, there is helpful advice on feeding and watering the animals (3 oz. of feed and ¼ pint of water a day at least), on ventilation, light and temperature, and on what to do in the event of sickness or injury.

Apart from dealing with the actual care of the monkeys, this standard is also concerned with the health of the animal handlers, and recommends that they produce evidence of fitness—including freedom from active tuberculosis; the compilation of an approved list of animal handlers, and of agents of importing firms, is in course of preparation.

These standard recommendations, based on valuable background work carried out by the Medical Research Council, will be followed by others dealing with various mammals, birds, fish, reptiles and invertebrates.

It is to be hoped in view of the press reports which occasionally appear concerning the high death rate of rhesus and other small monkeys during transit to this and other countries, this Standard will go a long way towards bettering the conditions of these extremely valuable aids to research.

Anglo-American Moon-echo Experiment

In August last radar signals transmitted from the Royal Radar Establishment, Malvern, at a wavelength of 10 cm. were successfully received in Texas after reflection from the moon. This is the outcome of a joint experiment between members of the Radio Astronomy Group at the Royal Radar Establishment, Malvern, and the Electrical Engineering Research Laboratory of the University of Texas, and is an extension of the programme by the Radio Astronomy Group on the study of the surface of the moon using radar.

The radar pulses, each of 5 microseconds duration and 2 megawatts power, were transmitted from the 45 ft. diameter radio telescope at a repetition rate of 250 pulses per sec. This equipment has been used previously for tracking the Soviet satellites and for moon echo experiments. Now the radar signals scattered back from the moon after a round trip of about ½ million miles have been received both by the radio telescope in Malvern and by a slightly smaller radio telescope at the University of Texas.

By comparison of the signals received at the two sites it is hoped to find out more about the surface conditions of the moon and also how the moon could be used as a reflector for transmitting radio and television signals for long distances over the surface of the earth.

Psychology in Industry

Dr. Norman Loveless, who is a lecturer in psychology at Queen's College, Dundee, has been appointed as a consultant to Smiths Aircraft Instruments Limited.

The growing application of experimental psychology to equipment design has from the first been closely associated with the problems of aircraft instrumentation, since it was recognized during the last war that the pilot's ability to respond quickly and accurately to the information with which he was presented could be improved by scientific study of his capacities and limitations. With the increasing speed of modern aircraft, this task has become still more urgent. Dr. Loveless has been engaged for some time in research in this field, and will advise Smiths in the light of the considerable body of knowledge which has been built up over the past 15 years.

Keith Miller 'Stumped'

Famous Australian cricketer Keith Miller was recently 'stumped' by Col. Sir William Leggatt, Agent-General for Victoria, at Victoria House in London.

The stump in question was a dimensionally correct hollow glass cricket stump, manufactured specially for Sir William by Quickfit & Quartz Limited.

Only the second of its kind in the world, the stump has been given to Miller to remind him of his many visits to England with past Australian Test teams.

Original glass stump reposes in the Little Stoke (Staffs.) Cricket Club pavilion, where players who take nine wickets or more, or score a century, are asked to drink a stump-full of ale without pausing, a variation of the better-known feat with yards of ale.

Glass Technology

A three-day technical meeting was held at Harrogate from September 19 to 23, 1959, at which a number of papers were read on matters relating to the history of the glass industry and the present position in regard to international trade and competition.

Speaking at the Annual Dinner of the Society, the President, Mr. J. B. Murgatroyd, M.A., F.S.G.T., said that the emphasis on scientific training had brought into perspective the importance of the professional society and emphasized the necessity for frequent exchanges of information between scientists and technologists. This was proved by the success of the recently inaugurated policy of holding meetings where a subject was discussed in various aspects by the producers and users of products of the glass industry.

This policy was to be further advanced by the division of the *Journal of Glass Technology* into two parts, to be issued as separate publications, namely *Glass Technology* and *Physics and Chemistry of Glasses*, as from February, 1960.

Keith Miller tries out his 'glass' of ale.

News from the British Association of Chemists

F.I.C.C.I.A.

The meeting of the Comité Directeur of F.I.C.C.I.A. arranged for October 3 and 4, 1959 had unfortunately to be postponed as it was found necessary to have a meeting of the Comité Directeur of the Fédération Internationale des Cadres in Paris on the same dates. As the President of F.I.C.C.I.A. and some of its Officers are members of this latter Committee, it was felt necessary to postpone the F.I.C.C.I.A. meeting. It has now been decided, however, to hold the next meeting of the *Assemblee Generale* of F.I.C.C.I.A. in London in May 1960. It is hoped to combine with this a short symposium on the work performed by certain of the F.I.C.C.I.A. special Committees.

I.L.O. Conference, Geneva—June, 1959

The seventh item on the Agenda of this Conference was 'Problems of Non-manual Workers, including Technicians, Supervisory Staff, etc.'

At this Conference the C.I.C. was officially represented by Dr. Ferrero (President of F.I.C.C.I.A.). According to the I.L.O. publication 'Industry and Labour' some of the conclusions adopted at the Conference were as follows:

1. Employment and unemployment, with special reference to the problems of the educated unemployed and of older workers: The I.L.O. should accentuate its studies of conditions prevailing in developing countries as regards the employment and unemployment situation, with special reference to the problems of the educated unemployed. It should prepare studies and, possibly, convene an *ad hoc* meeting on problems concerning the employment and re-employment of older workers, especially as regards vocational training and vocational rehabilitation, reclassification and retirement pension schemes.
2. Contract of employment: The I.L.O. should pursue or undertake studies on the form and content of the contract of employment, including contracts for temporary employment, of different categories of non-manual workers, as well as studies on the termination of the contract of employment of salaried non-manual workers and on the 'radius clause'.

Transfer of pension rights: The I.L.O. should pursue or undertake the examination of the problem of social security of non-manual workers from the point of view of the transfer of pension rights of workers moving from one employment to another.

3. Problems of individual categories of non-manual workers. Technical and supervisory staff: The I.L.O. should make a study of the position of supervisory staff in relation to the provisions of relevant Conventions and Recommendations. The I.L.O. should enquire into the practices of countries in granting recognition of diplomas or certificates of technical personnel trained in other countries, with a view to allowing persons in these categories greater mobility.
4. Inventors in salaried employment: The I.L.O. should make the necessary studies and preparations with a view to convening, as soon as possible, a committee of experts to consider the problems of the salaried inventor.

In connection with Items 2 and 4 above, two Resolutions, both of which were prepared by F.I.C.C.I.A., were put before the Conference by the C.I.C. This is the first occasion upon which 'Cadres' (Professional Men) have been able to put forward proposals through their official representative at an I.L.O. Conference. Chemists in Great Britain were represented there on this occasion through the B.A.C. and its membership of F.I.C.C.I.A. Members of the B.A.C. took part in the work of the F.I.C.C.I.A. Committees concerned with the protection of the interests of 'Salaried Inventors', the Operation of Restraint Clauses in Service Agreements and the International Equivalence of Degrees, Diplomas etc., as a result of which these matters figured in the discussions at the Conference.

All correspondence and enquiries concerning this Association should be addressed to G. R. Langdale, Esq., The British Association of Chemists, Nomination Dept., 14 Harley Street, London, W.1. Tel.: Museum 7021.

OBITUARY

Sir Ian Heilbron

It is with very great regret that we record the decease at the age of 72 of Prof. Sir Ian Heilbron, D.S.O., F.R.S., who was elected an Honorary Member of the B.A.C. in 1924 and subsequently made a Life Member.

He was born in Glasgow and educated at the Royal Technical College; he then spent two years with Hantzsch at Leipzig under a Carnegie Fellowship. He was appointed a Lecturer at the Royal Technical College in 1909. in 1915 he went overseas with the A.S.C. and became Assistant Director of Supplies in Salonika. He was awarded the D.S.O. and was mentioned tnree times in despatches. After a time with the British Dyestuffs Corporation in Manchester he returned to Glasgow as Professor in the College. He held chairs of organic chemistry at Liverpool (1920-33), Manchester (1933-38) and at the Imperial College of Science and Technology, London (1938-49). He then became the first director (1949-57) of the Brewing Industry Research Foundation. His scientific activities embraced many fields but he made his most valuable contributions to the chemistry of natural products and he was a pioneer in this country of the application of chromatography to their purification, and of ultraviolet light absorption to the determination of their structures. At a time when natural product studies were almost the monopoly of scientists in Germany and Switzerland, Heilbron successfully initiated researches in this country on polyenes and steroids and the interest in these fields manifest in many departments of chemistry in Britain today can be traced back to his inspiration.

His most notable contributions were to the chemistry of the vitamins of the A and D groups, to the determination of the structure of squalene (from shark liver oil) which has now assumed great biochemical significance, and to the chemistry of penicillin, especially in the recognition of its existence in a multiplicity of forms.

Future generations of organic chemists will no doubt remember the name of Heilbron in connection with his *Dictionary of Organic Compounds* first published in association with H. M. Bunbury in 1934/37, the third edition of which is now in preparation.

From 1939 to 1942 he was scientific adviser to the Department of Scientific Research of the Ministry of Supply and from 1942 onwards he was one of the three scientific advisers to the Minister of Production. During this time he recognized the potential value of the insecticide D.D.T. and took steps to see that it became available in sufficient quantities for the Italian and Far Eastern campaigns. From 1950 until 1954 he was the chairman of the Advisory Council for the Department of Scientific and Industrial Research.

His public services and scientific contributions have been widely recognized: by a knighthood in 1946 and awards of the Longstaff Medal of the Chemical Society and Royal and Davy Medal of the Royal Society. In 1945 he was the first recipient, outside of the United States, of the Priestly Medal of the American Chemical Society.

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Variable Speed Stirrers

The design of this stirrer is said to be unique in that the volts on the armature are controlled by an Autotransformer with multiple tappings, while the field windings are supplied with a constant high voltage.

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Titrator Amplifier

The scope of the recently introduced Eel titrator is now further increased by the introduction of the titrator amplifier. This, in conjunction with a special burette, provides for the accurate micro determination of chloride.

This instrument will be of interest in clinical laboratories for the analysis of biological fluids, such as plasma, serum and cerebro-spinal fluids, but may also be employed in food, agricultural and metallurgical laboratories.

A special burette is available with the unit. This is fitted with a sealed-in platinum electrode and has a fine silver wire down the outside of the tube. The burette is mounted above the titrator platform and the electrodes from this plug into the amplifier.

The sample is contained in special 10 ml. beakers and mounted on the stirrer platform of the titrator. When silver nitrate from the burette is mixed with the sample containing chloride, precipitation of the sodium chloride occurs until end-point is reached, after which the concentration of silver increases rapidly giving a change in the potential between the sodium electrode and the platinum electrode. This change is continuously indicated on the Eel Unigalvo Type 20. By titrating a known volume of chloride a reading is obtained which corresponds to the exact end-point potential between the silver nitrate and the chloride in the solution.

(Manufacturers: Evans Electroselenium Ltd., St. Andrew's Works, Halstead, Essex.)

Glassware for Schools

Three sets of organic preparation apparatus are now available for schools and colleges.

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(Manufacturers: Quickfit & Quartz Ltd., Stone, Staffs.)

New Stirring Aid

A series of porcelain stirrer heads is available in various shapes and sizes to suit a wide range of stirring conditions.

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(Available from: Orme Scientific Ltd., 17/23 Russell Street, Manchester, 1.)

CATALOGUES, BROCHURES & LEAFLETS

Received from Manufacturers

Laboratory Equipment. — Camlab (Glass) Ltd., 50 Burleigh Street, Cambridge, have published a small supplement (No. 1) to be used in conjunction with their first catalogue, published in 1957. Since that date they have greatly improved their ovens and incubators and the supplement contains details of these and a wide variety of other laboratory equipment.

B.D.H. Leaflets.—New entries in the catalogue of British Drug Houses Ltd., of Poole, Dorset, are listed in the August/September issue of their monthly leaflet. These are as follows: *Organic and Inorganic Chemicals.*—Anti-bumping granules; 3-chloro-propan-l-ol; 2:2-dimethyl-propan-l-ol; maleic hydrazide; trichloro-acetic acid for protein precipitation. *Wetting Agents.*—Nonidet P40.

Wild-Barfield Heat-Treatment Journal. —The September 1959 issue of the Wild Barfield Heat-Treatment Journal, published by Wild-Barfield Electric Furnaces Ltd., of Elecfurn Works, Otterspool Way, Watford By-Pass, and associated companies, contains articles on high temperature carburizing, brazing in electric furnaces and the usual section on abstracts and references.

Cold-Cure Silastomer.—Midland Silicones Ltd. of 68 Knightsbridge, London, S.W.1, have issued a booklet describing their cold curing silicone rubbers.

Laboratory Furniture.—Although primarily designed to help Education Authorities in the preparation of science rooms for secondary modern and grammar schools, a new brochure published by the North of England School Furnishing Co. Ltd., of Darlington, serves a useful purpose to those responsible for the planning of laboratories both for educational and industrial purposes.

Plastics in the Chemical Industry.—The increasing use of synthetic resins and plastics in the chemical industry is described in a new illustrated publication issued by the Distillers Plastics Group, Devonshire House, Piccadilly, London, W.1. The booklet illustrates a wide range of applications and indicates the special properties possessed by the different types of plastics materials which cause them to be employed.

A New Price List of Laboratory Chemicals.—Griffin & George, Ltd., of Ealing Road, Alperton, Wembley, Middlesex, have now completed distribution of their current price list of laboratory chemicals. The catalogue comprises 84 pages of general chemicals, AnalaR and micro-analytical (M.A.R.) reagents, and many pages devoted to microscopical stains, reagents for water analysis and other specialized items.

NEWS

Manufacturers' News

The Building Exhibition

Griffin & George Ltd. will occupy Stand 629 in the Gallery of the National Hall, Olympia, during the forthcoming Building Exhibition which opens on November 18.

They will be showing, in addition to a wide range of laboratory furniture in both metal and wood, scientific apparatus for soil mechanics including Rigden's apparatus, slump test apparatus, Vicat apparatus, etc.

The services of the Group's Technical Department will be at the visitor's disposal to discuss the selection of materials and layout for complete laboratory installations including the provision of service outlets, pipework, fume extraction etc.

The Building Exhibition will be the first occasion on which the Group's new style metal furniture will be displayed.

Is Your Pump Quiet?

Research work by Edwards High Vacuum Ltd. to silence the 'Speedivac' range of pumps began nearly five years ago, the first development being the 'Medivac', an unballasted pump designed for the medical field. Quiet running versions of 'Speedivac' gas ballasted pumps soon followed and the whole range, including both single and two stage pumps up to 15 cubic feet per minute, have been available for the past year.

All 'Speedivac' pumps are tested exhaustively for several days to ensure a better performance than their catalogue specification. These trials involve a prolonged period of continuous running, up to 96 hours, as well as tests to check ultimate vacuum and displacement. To test pumps for noise level, however, presented quite a problem, but one which was solved by the company's Instrument Research Laboratories who produced a suitable noise detector.

This instrument comprises a vibration pick-up transducer which was mounted on the spout of the pump under test to receive the noise and vibration transmitted through the metal. The electrical signal from a noisy pump takes the form of regular bunched audio frequency impulses produced by the pump during every compression stroke. The electrical circuit of the control unit is designed to be selective and sensitive to the pump noise impulse only. It is not sensitive to the presence of other vibration and noise which form a background in most engineering shops. 'Speedivac' quiet pumps can therefore be numerically evaluated and appropriate action taken if they fail to attain their test specification.

On receiving these latest pumps many purchasers have asked if it is possible to silence existing pumps. This led to the development of a quiet valve pack which can be fitted to older models of the Speedivac 1S50, 1S150 and 2S50 unballasted pumps. The effect is a considerable reduction in noise at the expense of some loss of ultimate vacuum. These valve packs cost 16s. 6d. and are extremely simple to fit. They are not, however, suitable for gas ballasted versions of these pumps.

B.T.L. Equipment in Stockholm

On the occasion of the Tenth Conference of Scandinavian Chemists, which took place in Stockholm during August 1959, an exhibition of instruments and apparatus was held at which Baird & Tatlock (London) Ltd., in collaboration with their Scandinavian Agents, Instrumentfirma Labora, showed a selection from their ranges of Analmatic automatic laboratory instruments and equipment for chromatography and electrophoresis. The apparatus was demonstrated by Mr. E. G. Thomson, the Technical Sales Manager of Baird & Tatlock (London) Ltd.

Lord Hailsham at the opening of the new WarrenSpring Laboratory, the work of which is outlined on pages 377 *et seq.* in this issue of LABORATORY PRACTICE.

In the major changes in the structure of the Government recently announced from Downing Street, Lord Hailsham is now Lord Privy Seal instead of Lord President of the Council and as such takes over the new duties of promoting scientific and technological development.

The testing section of the laboratory in the new Ferranti extension.

Ferranti Extension to Edinburgh Laboratory

Mr. Aubrey Jones, M.P., the Minister of Supply opened the new £150,000 extension to Ferranti's existing laboratory at Crewe Toll, Edinburgh. This will be used for the production of a new series of high-precision gyroscopes and accelerometers for inertial navigation systems used in aircraft, missiles and other vehicles. This new extension will provide a completely integrated development and manufacturing unit.

Entirely functional in appearance and providing an additional floor area of approximately 17,400 sq. ft., the new single storey building is one of the most modern of its kind in the country. It comprises machine and process shops, assembly and test areas, stores, laboratories and offices.

Evershed & Vignoles Expand Canadian Organization

Evershed & Vignoles Ltd. have announced the re-organization and enlargement of their Canadian activities for the formation of a new company which is to be known as Evershed-Powertronic Ltd. The company will operate from Toronto and will provide a complete, coast-to-coast specialist sales and service organization for the installation of automatic electronic control equipment. This is a consolidation following the many recent successes of Evershed & Vignoles (Canada) Ltd. in obtaining contracts for important electronic control installations, such as those in Calgary, Vancouver, Newfoundland, Wabamun and other places.

The ranges of Megger insulation testers and other electrical testing instruments manufactured by Evershed & Vignoles Ltd. will continue to be handled in Canada by R. H. Nichols Ltd., who have sole rights.

MEETINGS OF THE MONTH

Mid-November to Mid-December

We give below a selection of meetings of interest to laboratory workers. Details are as full as possible at the time of going to press, but readers requiring further information or confirmation of arrangements should contact the organizers.

November 10

The Society of Instrument Technology (Manchester Section). At the Manchester Room, Central Library, St. Peter's Square, Manchester, 1. 6.45 p.m. 'Transistors,' by S. S. Goldburg.

November 12

The Society for Analytical Chemistry (Midlands Section). At the University, Birmingham, 3. 6.30 p.m. Meeting on 'The Identification and Determination of Phenols,' by Dr. L. Barker.

November 13

The Society for Analytical Chemistry (Scottish Section). At the Royal College of Science and Technology, Glasgow. 7.15 p.m. Joint meeting with the Royal Institute of Chemistry on 'Techniques in Radiochemistry for Analysis and Research,' by D. A. Lambie, followed by a display of appropriate equipment by A. R. Bolton & Co., Edinburgh.

November 20

Royal Institution of Great Britain. At 21 Albemarle Street, London, W.1. 9 p.m. 'Atoms and Molecules,' by Sir Lawrence Bragg.

November 26

The Society of Instrument Technology (Chester Section). At the premises of the English Speaking Union, Stanley Palace, Watergate Street, Chester. 7 p.m. 'Science in the Detection of Crime,' by A. Thompson.

November 27

Royal Institution of Great Britain. At 21 Albemarle Street, London, W.1. 9 p.m. 'Research in the War against Locusts,' by Dr. P. T. Haskell.

December 2

The Society of Instrument Technology (Cheltenham Section). At the Belle Vue Hotel, Cheltenham. 7.30 p.m. Films on Transistors.

December 3

The Society for Analytical Chemistry (Scottish Section). At the Central Hotel, Glasgow. 7 p.m. The Ramsay Dinner.

December 4

Royal Institution of Great Britain. At 21 Albemarle Street, London, W.1. 9 p.m. 'Electronic Brains,' by Dr. H. A. Thomas.

B.F.M.I.R.A. OPEN DAY

Food Research Association's Open Day showing work in connection with the moisture sorption of starch.

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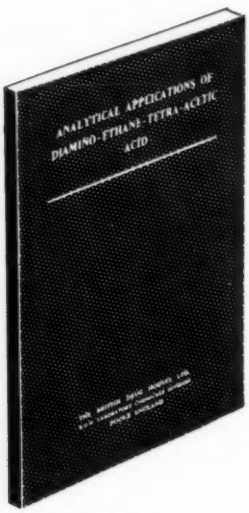

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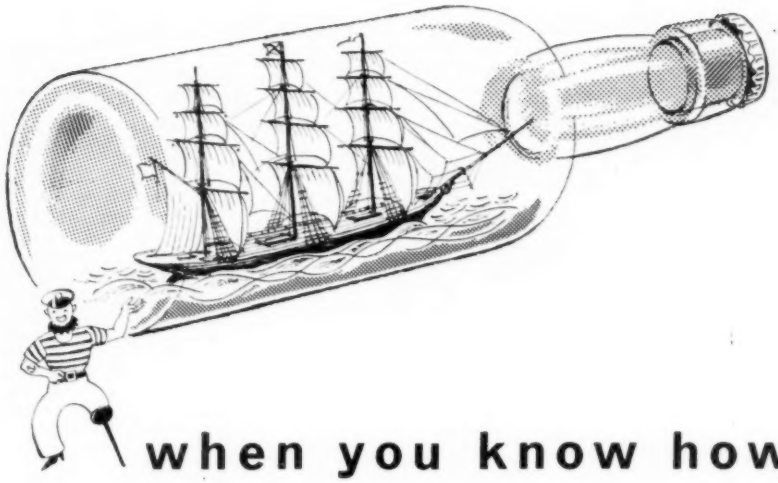

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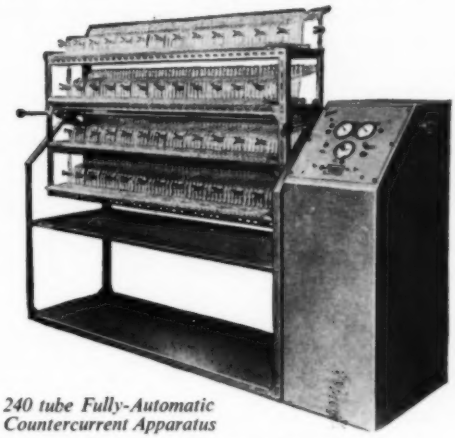

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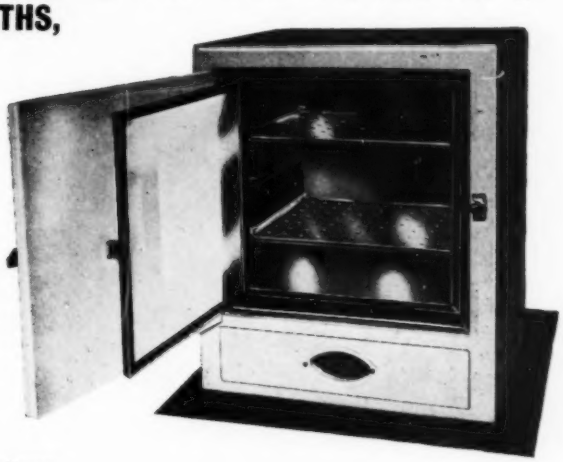

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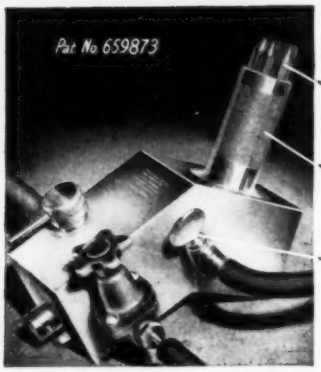

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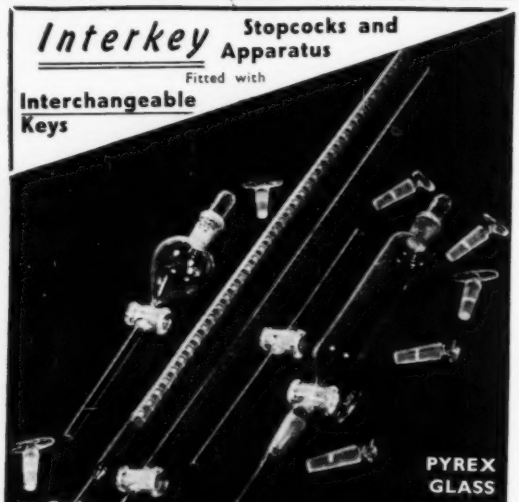

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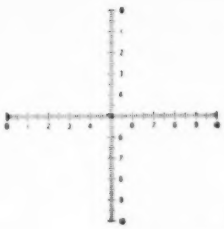
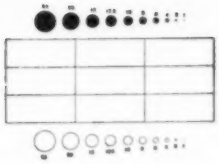
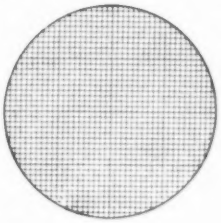
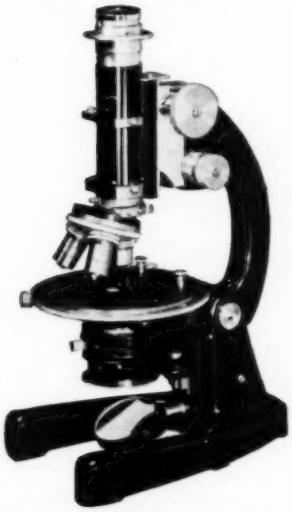
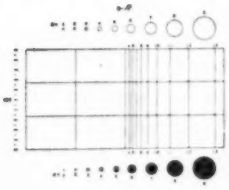
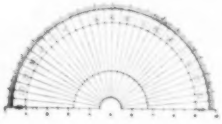
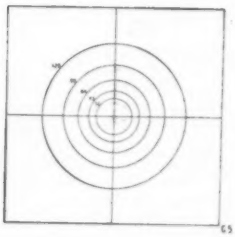

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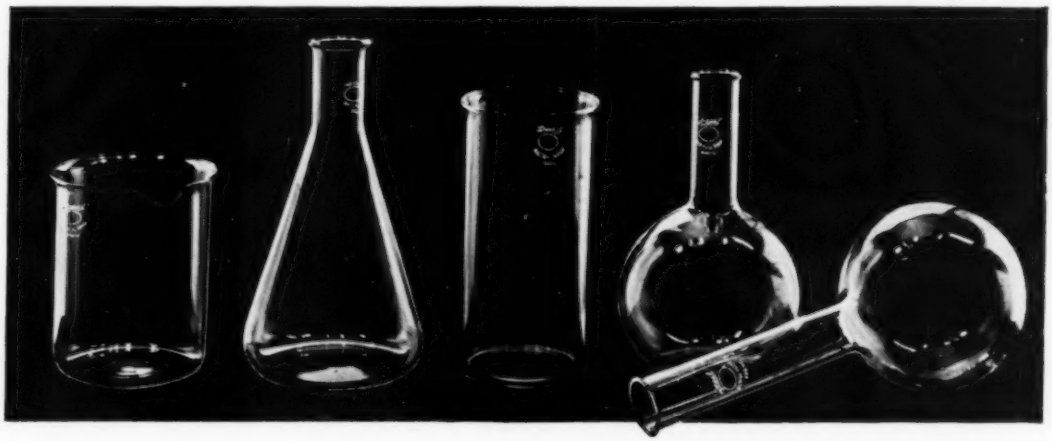

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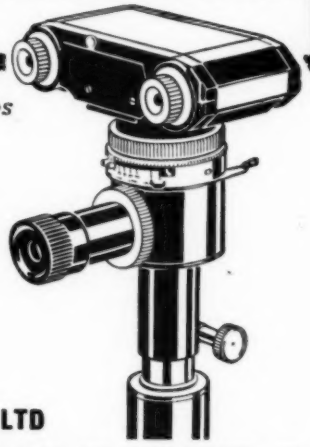

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